



SCIENCE a modern approach

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SCIENCE



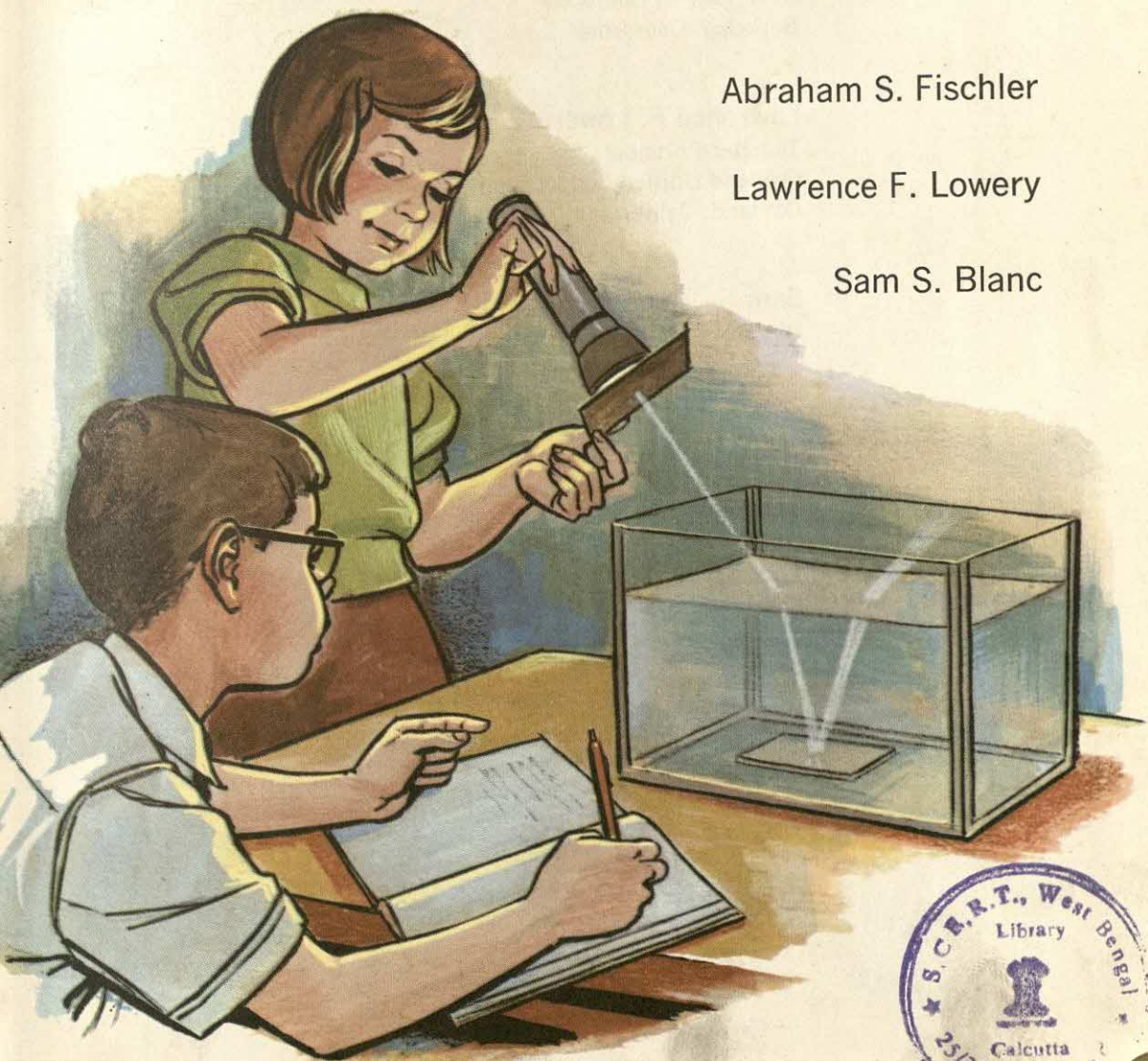
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to 15-1-87

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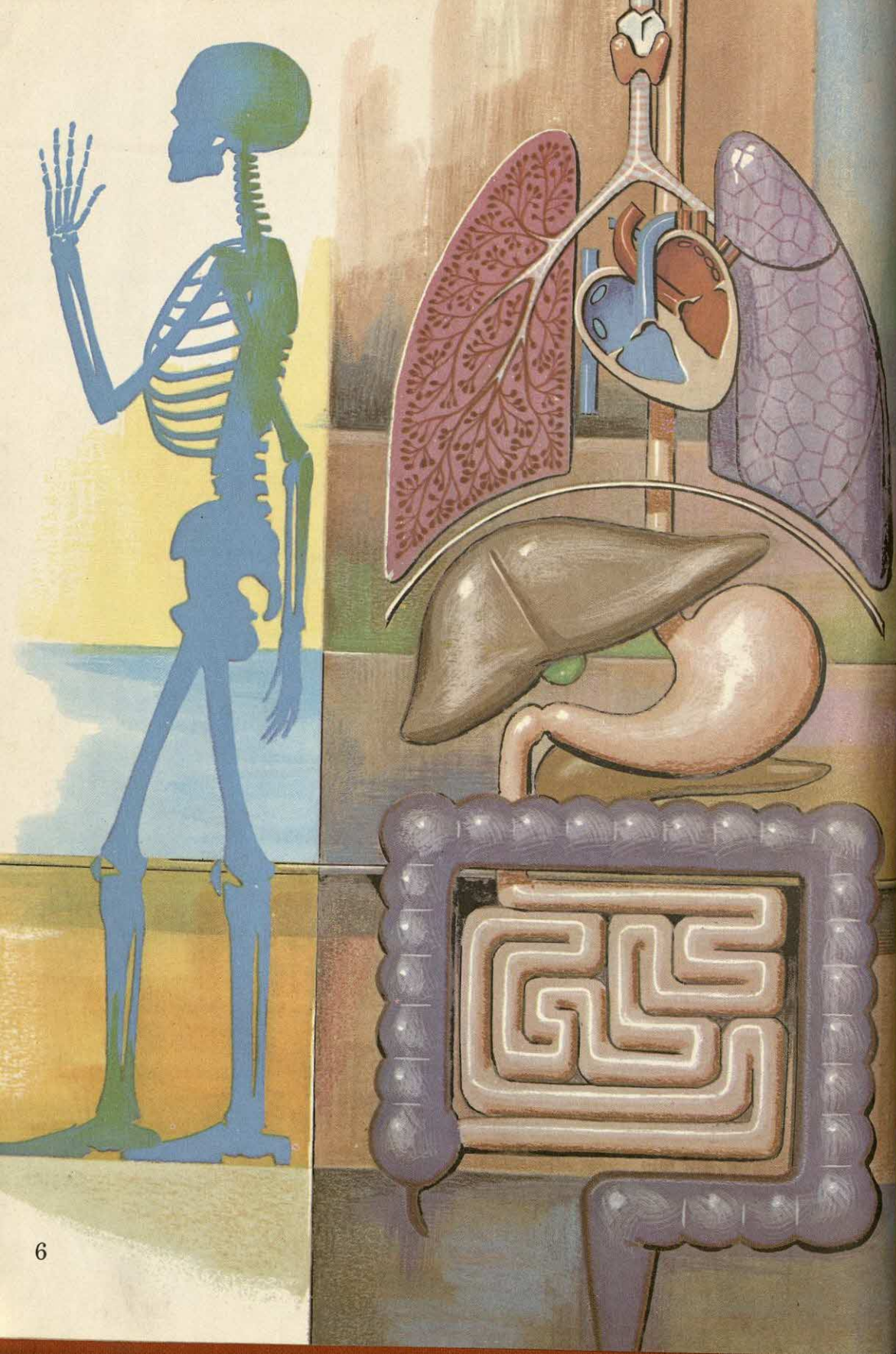
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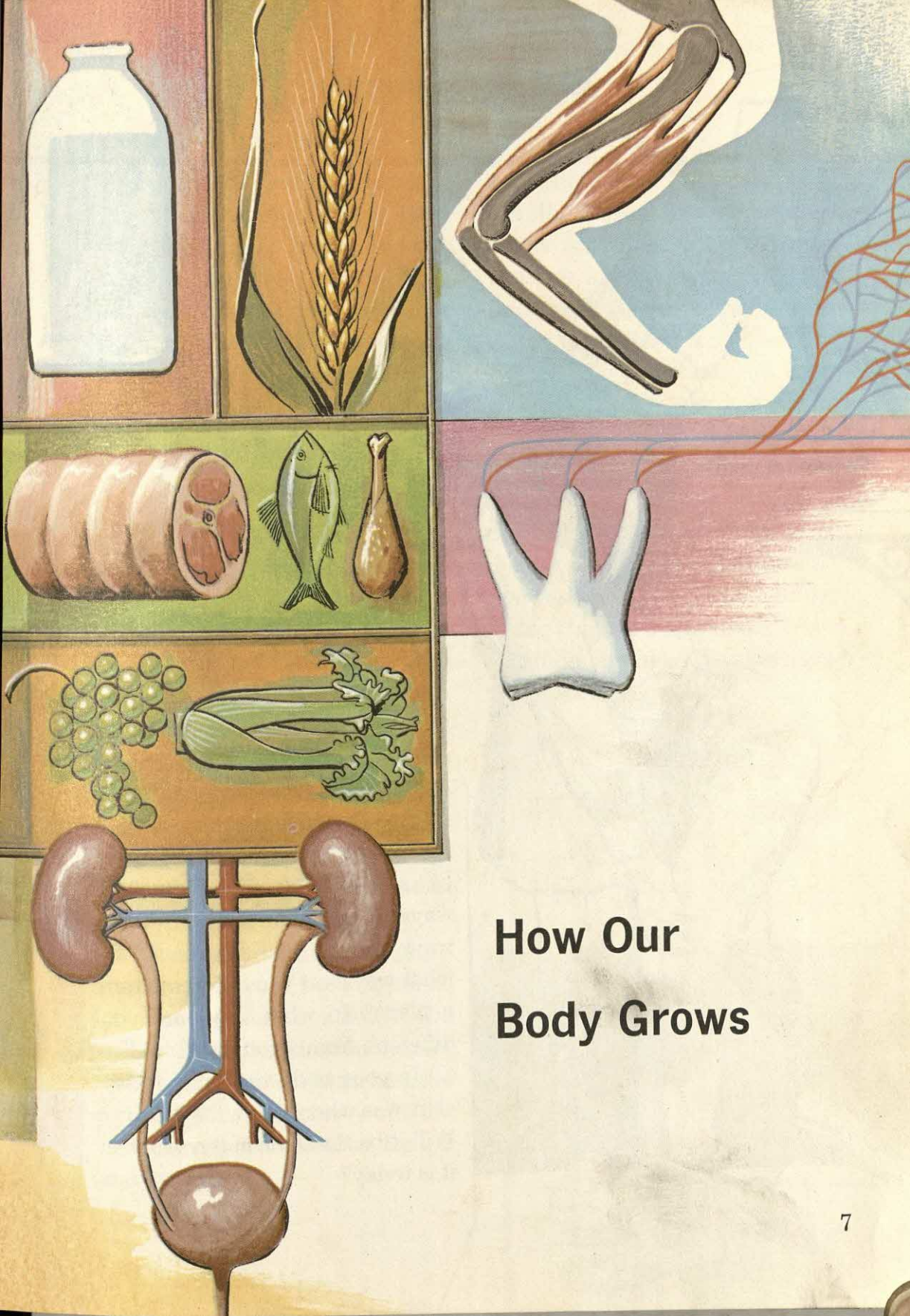
Printed in the United States of America

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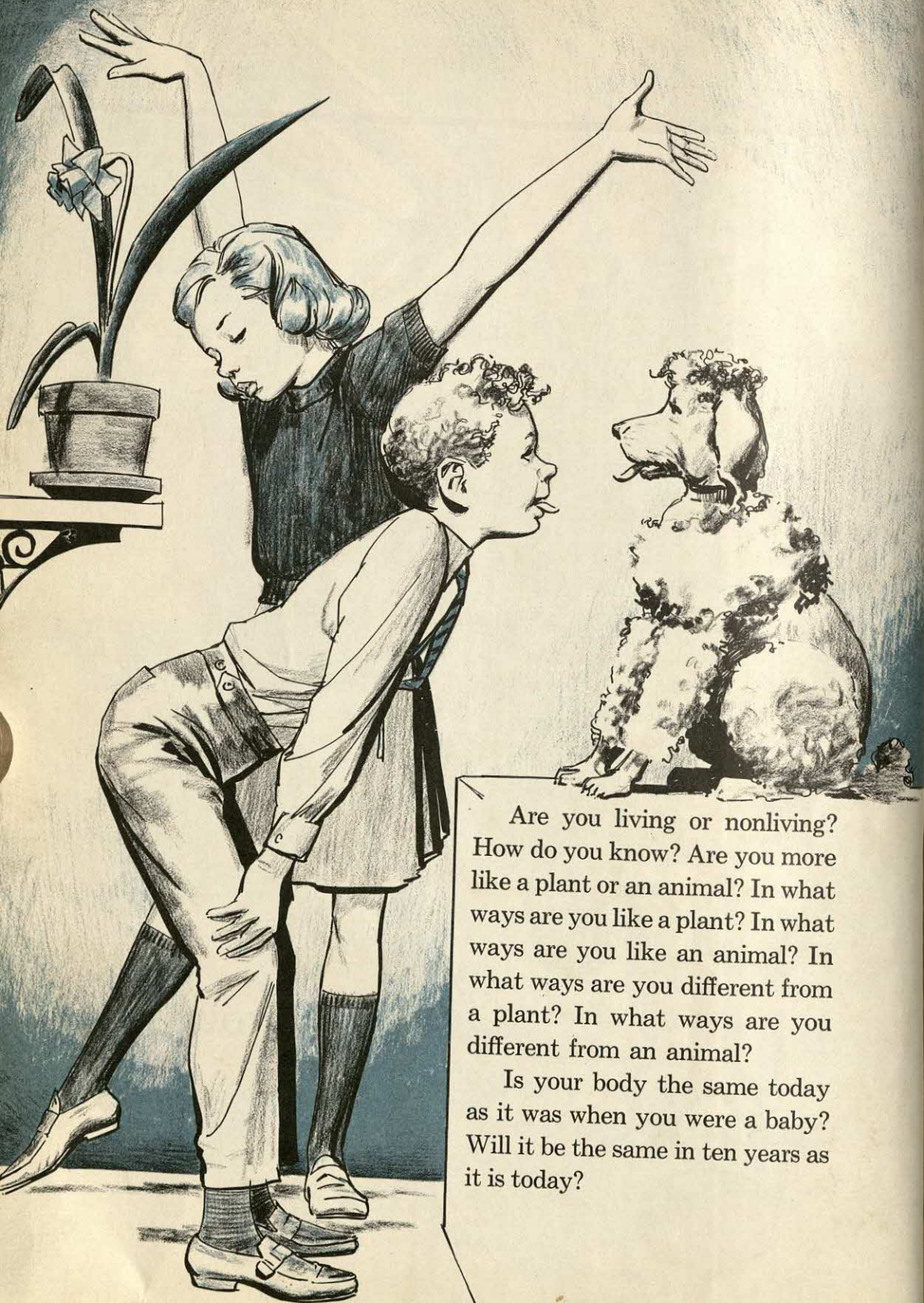
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How Our Body Grows



Are you living or nonliving?
How do you know? Are you more
like a plant or an animal? In what
ways are you like a plant? In what
ways are you like an animal? In
what ways are you different from
a plant? In what ways are you
different from an animal?

Is your body the same today
as it was when you were a baby?
Will it be the same in ten years as
it is today?

Your Growing Body

Knowing About Growing

In this unit, you will learn how the different parts of your body work together to help your body to grow and move, and to carry out the activities that keep your body healthy. The things you learn will help you to take care of your body. They will help you to be healthy now, and to stay healthy in the future.

The Human Organism

Each living thing whose parts act together as a unit is called an organism (OR-gan-izm). Each part carries out certain activities to keep the organism alive. Some organisms have fewer parts than others. Still other organisms are much more complicated. The human organism has many, many parts. For the parts to carry out their activities, they must be in good condition.

The arrangement of the physical parts of your body is called the structure of your body. You will learn about the structure of your body. You will learn how the parts of your body carry out the activities that are needed for life and growth.

All the parts of the body that work together as a unit to carry on one life activity form one system of the body. The bones all work together as the strong, movable framework of your body. Together, the bones are called the skeletal system. What are some other systems of your body?

Each part or member of the system is an organ, which acts in its own way to help the body carry on the life activities. How many organs of the skeletal system can you locate? Put your ear to the chest of a classmate. What organ do you hear? To what system does it belong?

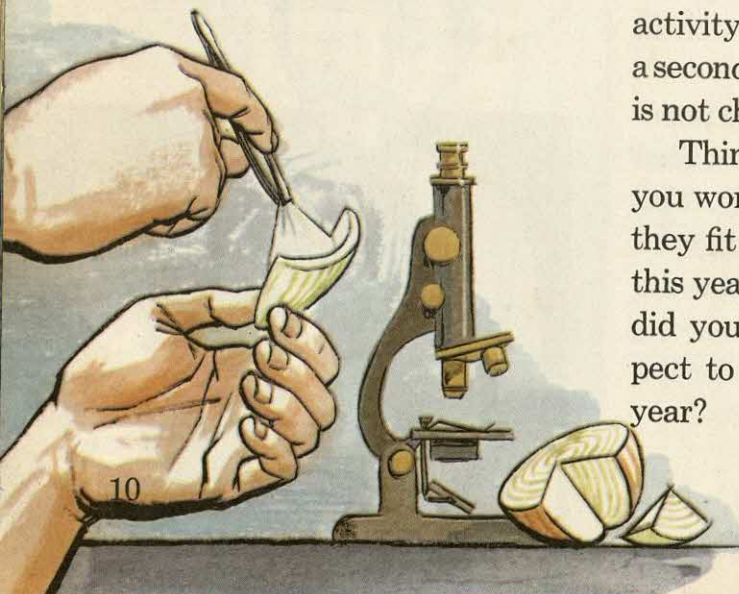


Each organ of your body is made up of special materials that are suited to the function the organ performs. The material of which an organ of a system is composed is called tissue. Your bones, heart, and skin are made of different types of tissue.

EXPLORE

Peel off a piece of onion skin. Try to get the piece as thin as possible. Put this piece of onion skin on a moistened glass microscope slide. Examine the onion skin under a microscope. Is a tissue one continuous piece of material, or is it made up of many parts? If it is made up of parts, are these parts alike or different? □ □

The microscopic parts of the tissue are called cells. Your entire body is made of cells which grow and multiply as your body grows.



Your Body Grows

Growing is a very important activity of your body. There is not a second of the day that your body is not changing in some way.

Think about the clothes that you wore last year. Do you think they fit you better last year than this year? Did they get smaller or did you grow taller? Do you expect to be shorter or taller next year?

The Skeletal System

What Are Bones Like?

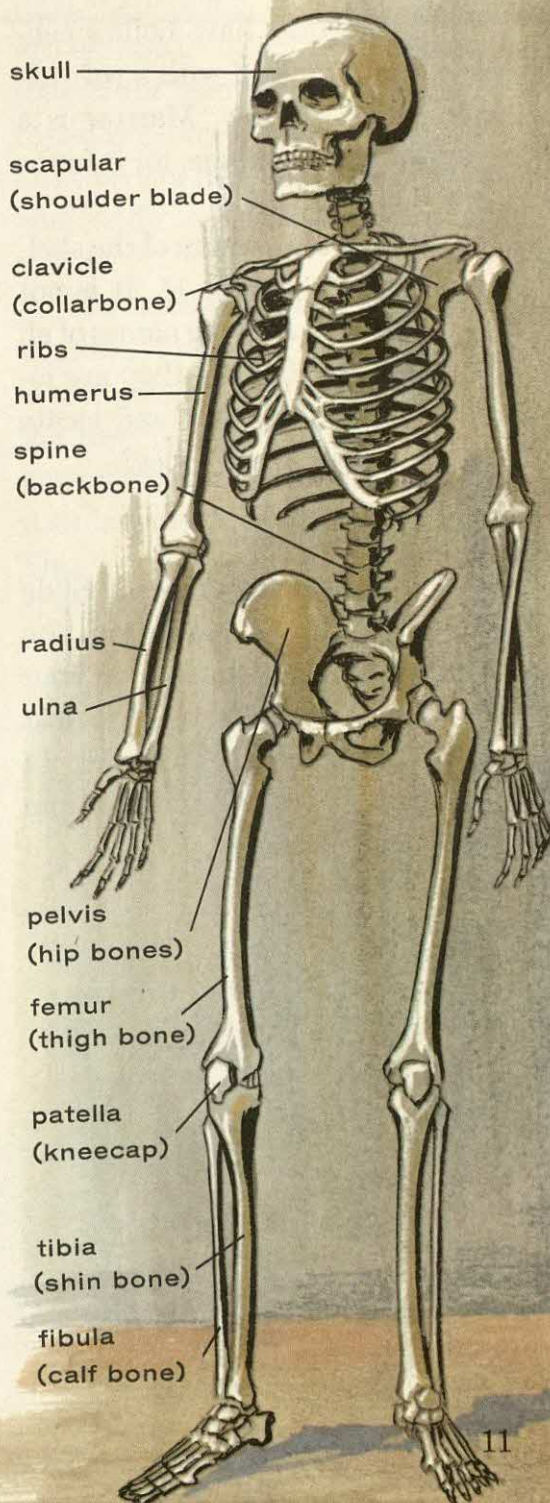
Stretch your arms out in front of you. Have they grown since you were in first grade?

INVESTIGATE

With your right hand, hold the tip of a finger on your left hand. Squeeze slightly along the sides of the finger to the palm of your hand, then to the wrist, forearm, elbow, upper arm, and shoulder. Do you feel bones inside? Which are the long bones? Which are the short bones? ☐ ☐

Bones are organs of the body. The system of bones that forms the framework of your body is the skeletal system. This system supports the muscles that are attached to the bones and helps you to sit and stand erect. How do bones protect certain organs? What system do you think gives the basic shape to the human body?

When you were born, your skeleton was not as hard and firm as it is now. Much of it was made of a rubbery tissue called cartilage (KAR-ti-lij). As you grow, most of the cartilage is replaced with special bone tissue that is stronger than other tissues in your body.



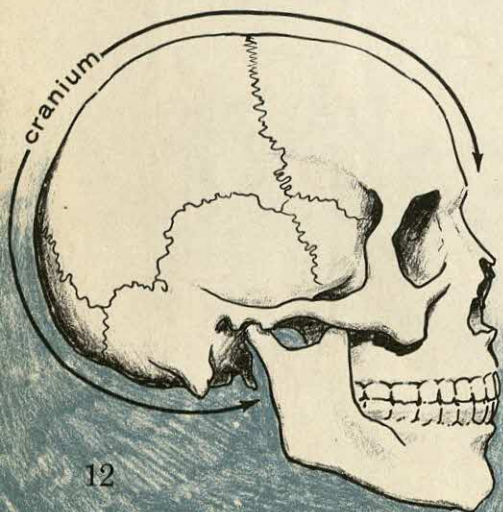
By the time you are fully grown, your body will have built about 200 bones.

Many bones have hollow centers that are filled with a soft tissue called marrow. Marrow is a very important tissue, for it forms blood cells.

Look at the picture of the skeletal system on page 11. It is not necessary to know the names of all the bones and where they are located. Can you name and locate some of the larger bones?

Bones of the Head

Where is your forehead? Slide the palm of your hand from the forehead, across the top of your head, and down the skull to just above your neck. This part of the head is called the cranium (CRAY-nee-um).



When you were born, the top of your cranium was made of cartilage tissue. In time, the cartilage was replaced by hard bone tissue. The cranium covers and shields the brain.

DISCOVER

Close your eyes and put a finger on the bridge of your nose, right between your eyes. Now draw your finger down to the point of your nose. Can you feel where the bone ends? How does it feel? How is this tissue different from bone? If you feel directly under your eyes, you will locate your cheek bones. Do these bones move when you open and close your mouth? Where is your lower jaw located? These are merely some of the bones of your cranium and face.

Bones of the Trunk

The main part of your body, excluding the head, arms, and legs, is called the trunk. It contains many bones that protect important organs such as the heart, the lungs, and the liver. Many of these bones can be felt through the skin, particularly the ribs, the collarbone or clavicle, and the backbone or spinal column.

OBSERVE

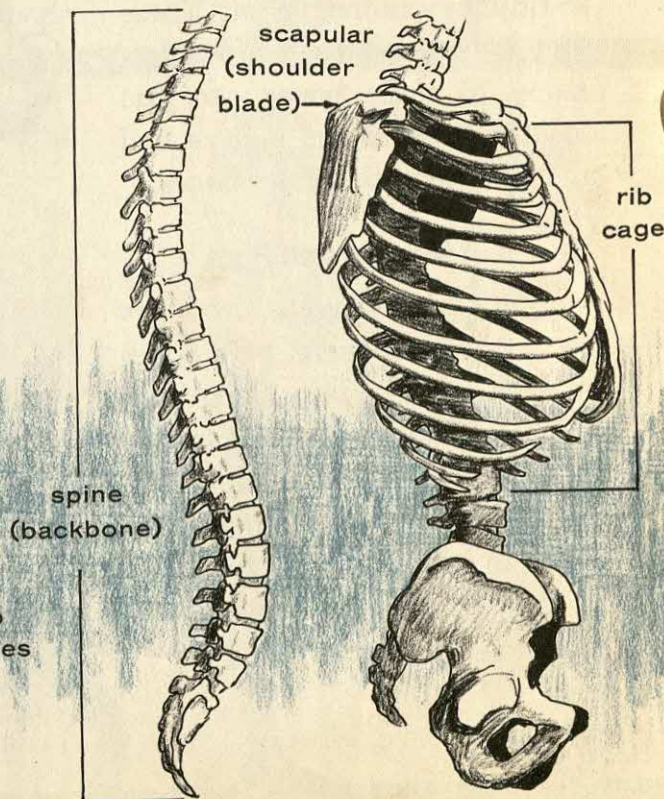
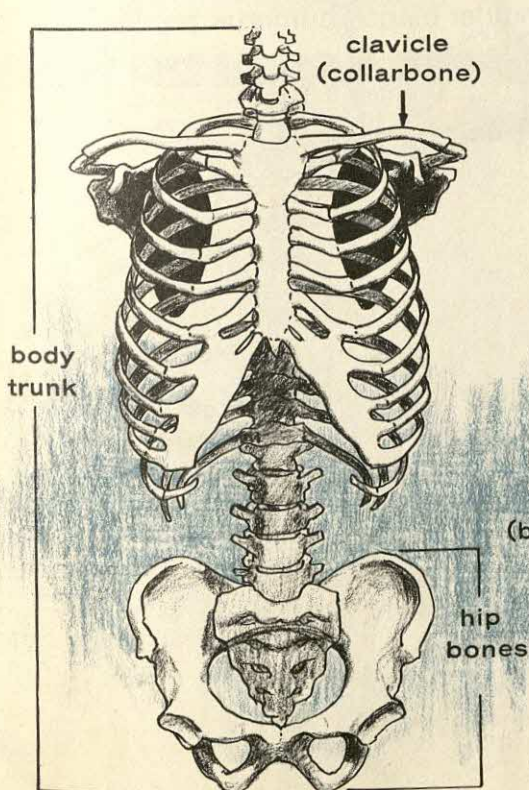
With the aid of a mirror, you can see part of your shoulder blades and some of the ribs at the base of your neck. By placing your thumb under your arm and moving it down along the side of your body, you are sure to feel other ribs. There are usually 24 ribs. They form the rib cage.

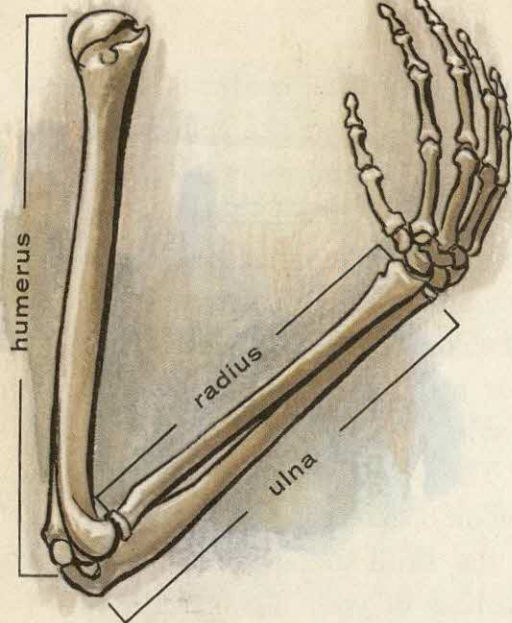
Put your hands around your waist and press down. Your hands fit directly over the bones that form your hips. How do your hip bones help you? □ □

One of the most important parts of your body's framework is

located down the center of your back. It is called the spinal column. Your spinal column is made up of small interlocking bones that work like hinges. Without these hinge-like joints, you could not shake or nod your head, bend your body, or move it from side to side.

The spinal column forms a shallow S, extending from the base of the skull along the back to the base of your hip bones. The most important nervous tissue in your body is in the spinal column. This tissue connects all the nerves of the body to the brain.





Bones of the Arm and Hand

In your arm, extending from shoulder to fingertips, there are bones of many sizes and shapes. Some of the bones of the hand are so tiny they cannot be felt. There are 32 bones in each arm. How many of these bones can you locate? Look at the picture and name three of the larger bones.

Bones of the Leg and Foot

Your entire leg goes from the hip to the toes. There are 31 bones in each leg. The large, long bone extending from the hip to the knee is called the femur (FEE-mur). This bone supports the part of your body called the thigh. Measure this bone and see how long it is.

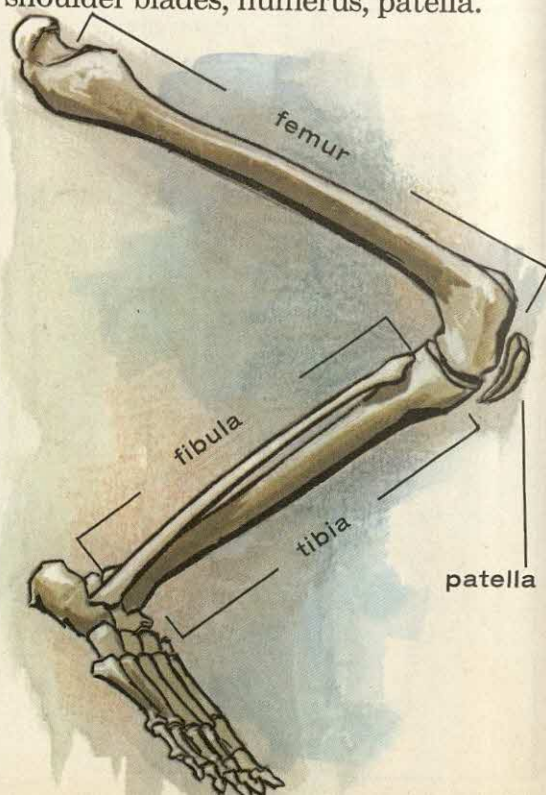
Feel the little round bone that sits on your knee joint. It is called the kneecap or patella (pa-TEL-a).

The lower part of your leg is formed from two long bones. You can locate the shin bone at the front part of your leg, a little toward the inner side. The other is the calf bone. It is toward the back and outer part of your leg.

The bones in your feet and toes are small. They are like the bones in your hands and fingers.

All bones have special names. Look at the picture on page 11. You will see what these names are.

Find your skull, trunk, spine, hips, femur, cranium, clavicle, shoulder blades, humerus, patella.



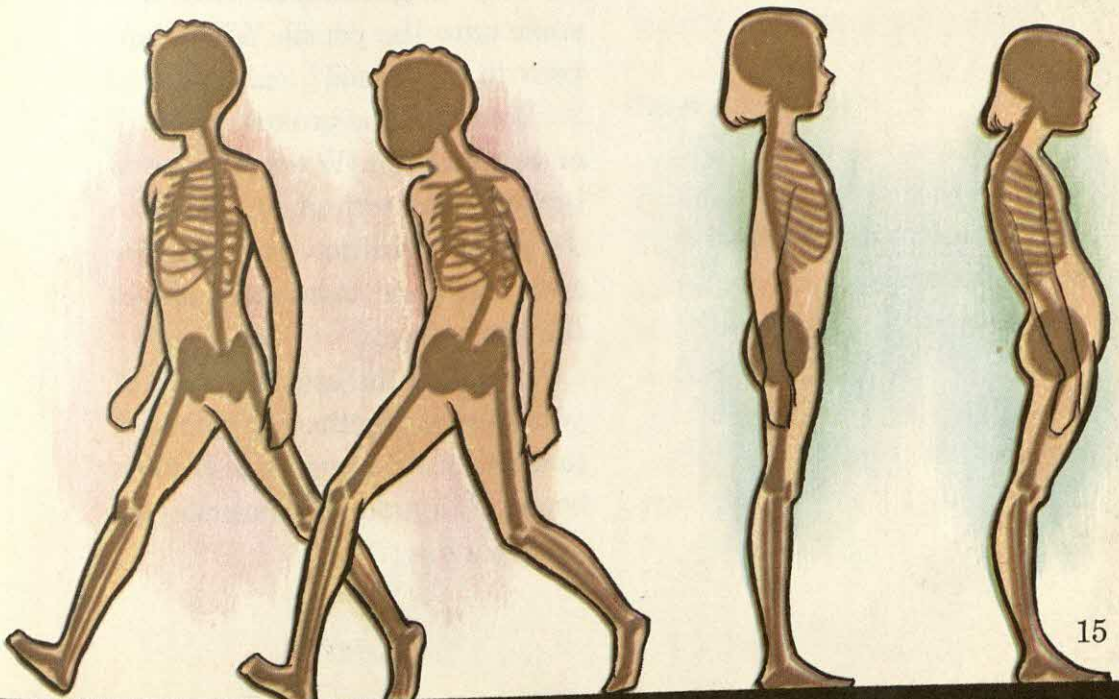
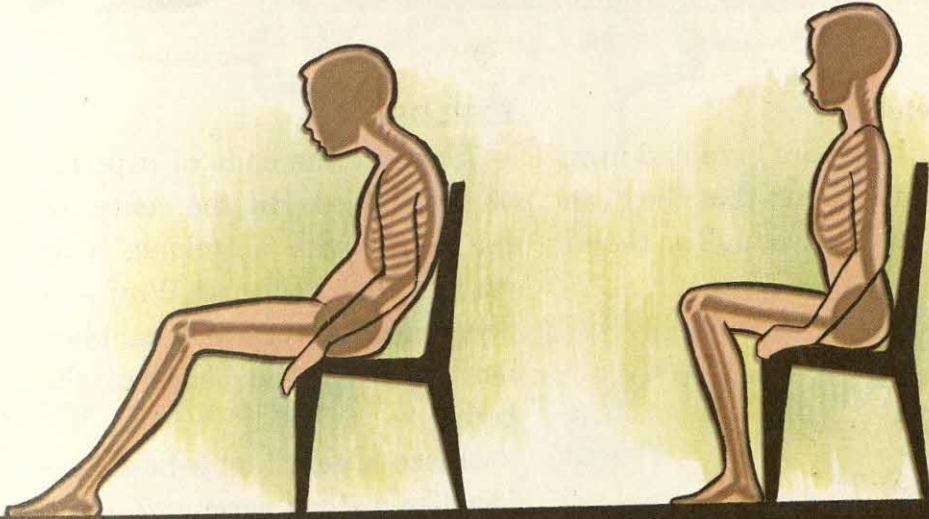
Good Posture

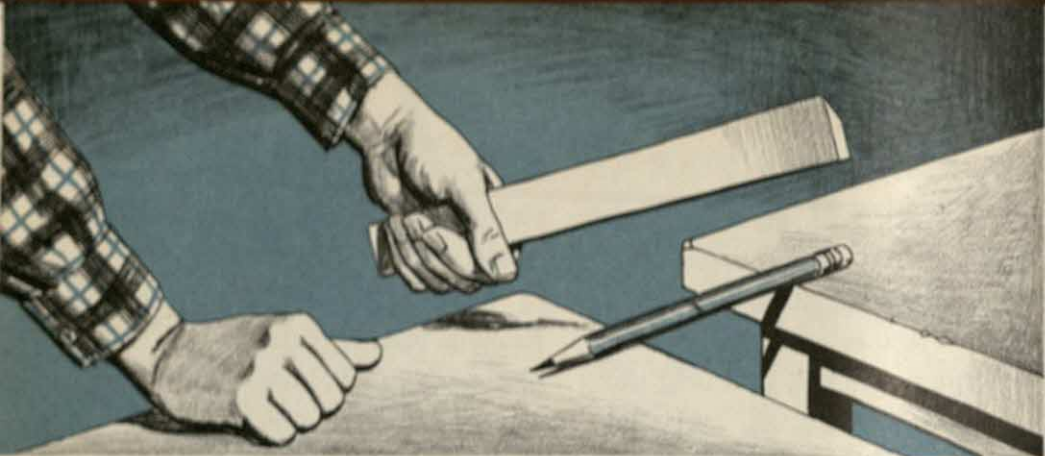
You are still growing. Your bones are still being formed. The way you stand, sit, and walk will affect the way your bones form.

Watch yourself in a long mirror as you stand, sit, and walk.

Compare what you see with the pictures below. How can you improve your posture?

Why is posture important? Explain how the children below are helping or hurting the formation of their skeletal systems.





Be Careful

Your bones are hard and firm, but does this mean that they can support any push or pull on them?



EXPLORE

Support the ends of a pencil on two tables. Hit the center of the pencil with a sudden, hard crack. What happens? Why is it dangerous to receive a sudden, hard blow on the bones of the body?

Place a pencil on a hard surface like a stone pavement. Drop a heavy weight like a brick or a stone onto the pencil. What happens to the pencil? □ □

Bones can be broken, twisted, or crushed too. When a bone is broken, a doctor puts it back into its proper position so that the ends can grow together again in the proper way.

If you fit the broken pieces of your pencil together, it will look something like certain broken bones. Why do football players wear padding?



The Muscular System

Muscles for Motion

Muscles are the organs of motion. You have control of some muscles. You can move them when you want, and stop their motion when you want. They are called voluntary muscles. Move some of your voluntary muscles.

There are other muscles that you do not control. These are called involuntary muscles. Your heart is an involuntary muscle. Do you have to think about your heart in order for it to beat?

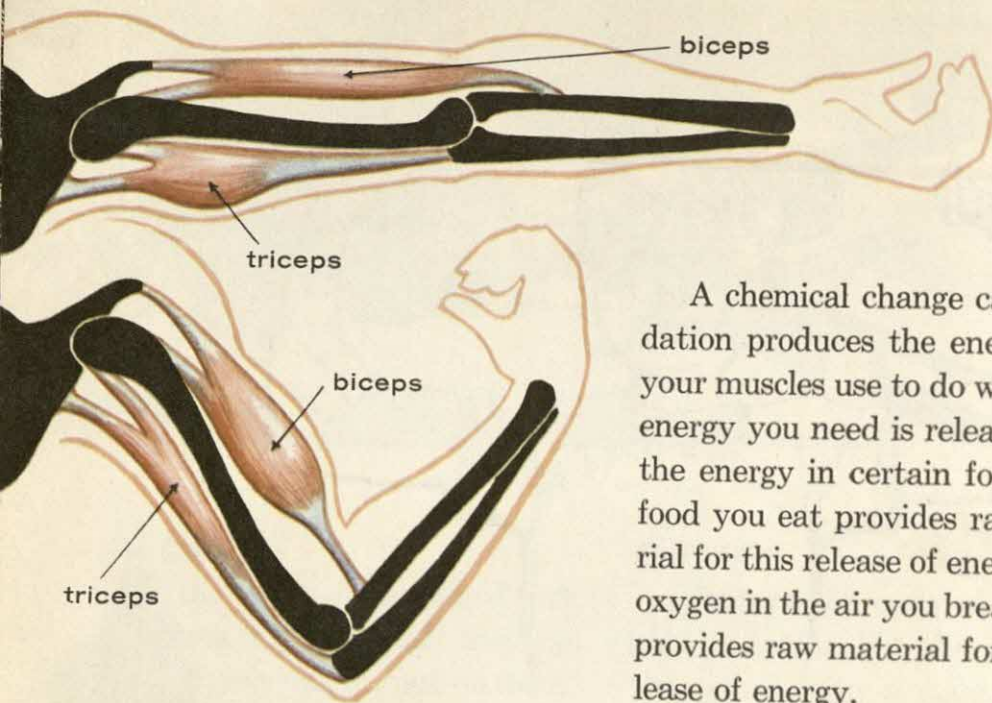
A few muscles are both voluntary and involuntary. You can

control them, but most of the time they work without your thinking about them. The muscles that control your breathing are muscles of this kind.

Skeletal Muscles

The muscles that move the bones of the skeleton are called skeletal muscles. They are voluntary muscles. Each skeletal muscle is attached to two bones, and usually works as one of a pair. When one muscle of a pair tightens, the other muscle of the pair relaxes.





OBSERVE

Look at the muscles of your upper arm. Feel them. The muscle on the front of your upper arm is called the biceps. When the biceps contracts, it becomes shorter and fatter, and pulls on the bones of your forearm. This action bends your arm.

Look at the muscle over the back part of your upper arm. This is called the triceps. As the triceps contracts, the arm straightens out. The triceps becomes shorter and stouter.

Muscles and Energy

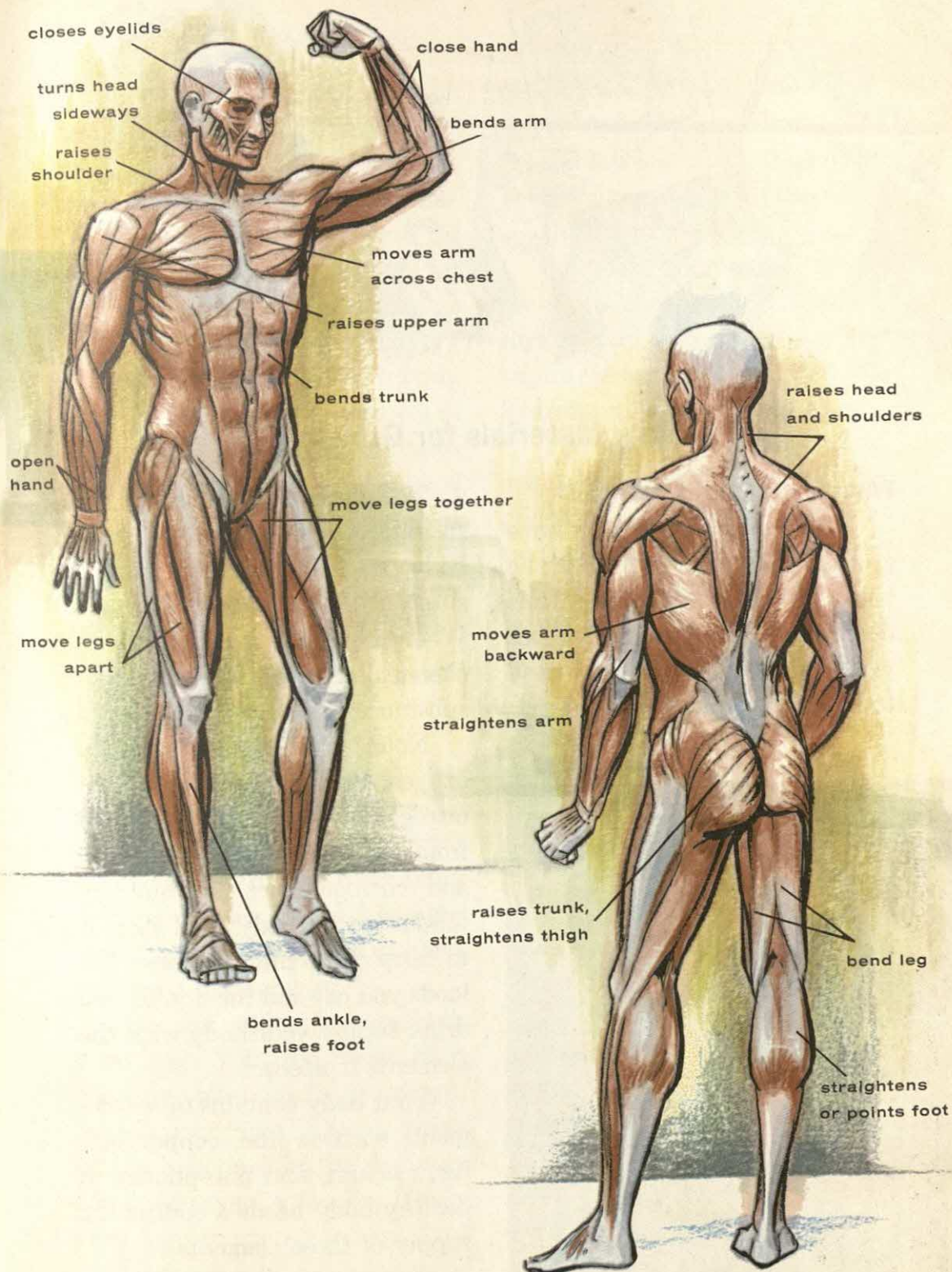
What is energy? Your muscles need energy in order to move.

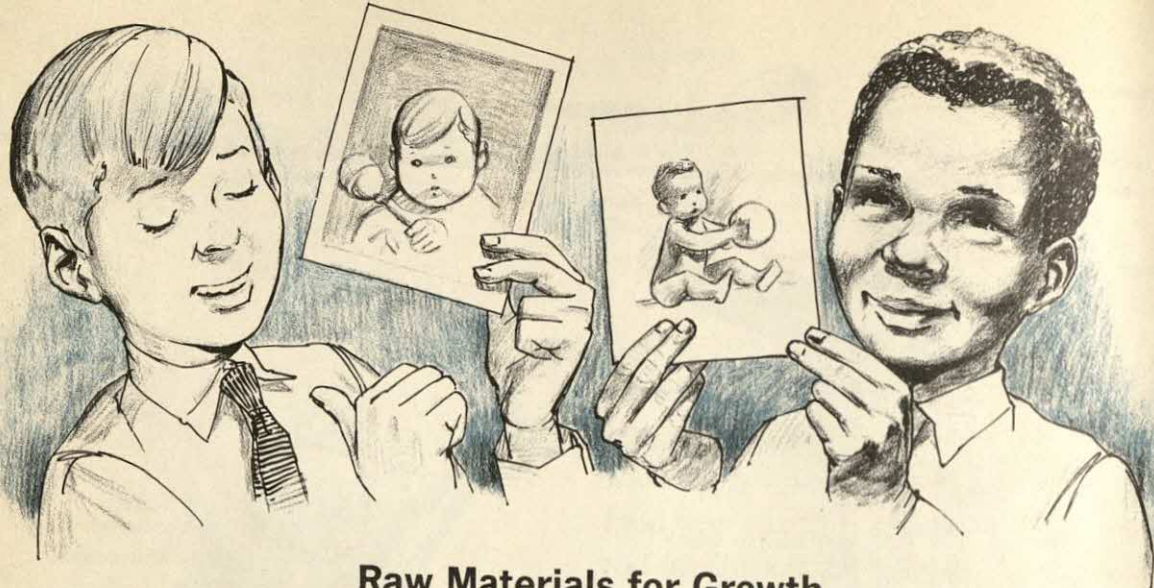
A chemical change called oxidation produces the energy that your muscles use to do work. The energy you need is released from the energy in certain foods. The food you eat provides raw material for this release of energy. The oxygen in the air you breathe also provides raw material for this release of energy.

Energy can be stored in the tissues that make up your muscles. Continuous muscular activity uses up stored energy quickly. Why do so many sport activities include rest periods for the players?

Your stomach, intestines, and heart are examples of organs made up of involuntary muscles. Energy is needed to keep these muscles moving, too. You will learn more about these organs when you study the other systems of the body.

What is the chief function of a muscle? How do the muscles of your body move? Do you use muscular energy when you are sleeping?





Raw Materials for Growth

What Is the Body Made of?

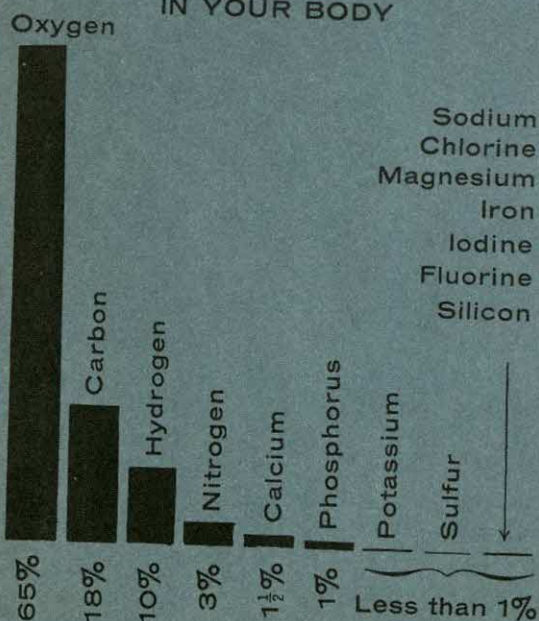
You can see that you have grown. You are no longer the baby you see in photographs. How much have you grown since last year? What does your body need to keep it growing properly?

The graph shows many of the substances contained in your body. Each of these is a simple substance. Each is an element. When elements combine in a chemical change, they form new substances called compounds.

Notice the large amounts of oxygen, carbon, hydrogen, and nitrogen. The compounds formed from oxygen, carbon, hydrogen, and nitrogen act as building blocks in the body, and help it to carry on its life functions. The foods you eat and the liquids you drink supply your body with the elements it needs.

Your body contains other elements such as iron, copper, sulfur, calcium, and phosphorus. A healthy body needs a continuing supply of these elements.

THE ELEMENTS
IN YOUR BODY



Supplying the Body's Needs

The foods you eat are the chief source of the elements your body needs for growth. Your body needs other things as well. Certain pure substances found in foods provide you with energy for work and play. Other substances in foods provide you with the very chemicals out of which your body is built. Other pure substances in foods help to keep all of your body's parts and systems in good working order. Many different kinds of pure substances have been identified in foods. These substances are called nutrients (NOO-tree-ents).

Energy Foods

You have a complex body that performs many difficult tasks. To stay "on the go," to keep your heart pumping, to do work, to stay warm in winter and cool in summer, and even just to stay alive, you must have energy.

A motor and a furnace both burn fuel. You, too, must burn "fuel" in your body to get energy; food is your "fuel." Do not think of foods as fuel in the ordinary sense, however. A fire burns at a very high temperature and gives

off light. Your body regulates the combination of foods with oxygen to get energy and warmth. You "burn" foods at about 99 degrees F, a temperature lower than that at which any fire could burn.

Our best sources of energy are foods that contain starches, sugars, and fats. Starches and sugars are sometimes called carbohydrates (*car-bo-HI-drayts*).

The word "carbohydrate" itself tells us what is in starches and sugars. "Carbo" tells us that carbon is present. "Hydr" tells us that hydrogen is present. "Ate" is the chemist's way of showing that oxygen is present.

EXPLORE

You can easily find out what foods contain starch. Iodine turns deep blue or purple in the presence of starch. Drop some tincture of iodine on several kinds of foods—raw potato, bread, cereal, cornstarch, a cracker, and an apple. Which contains a greater amount of starch—a very green apple or a very ripe apple?

Dissolve a beef bouillon cube in hot water. Then add iodine, drop by drop, to the liquid. Does the cube contain starch?

S.C.E.R.T., West Bengal

Date 15-1-87

Acc. No. 3747



Test other solutions. Make a list of the foods that contain starch.

<i>Foods Tested for Starch</i>	
Yes	No

OBSERVE

Here is a simple way to test foods for the presence of fats. Rub a piece of bacon on a sheet of

brown paper, and heat the paper over a radiator. Hold the paper up to the light, and notice the appearance of the spot on the paper. With a medicine dropper, drop water on the same sheet of brown paper. Again heat the paper over a radiator and then hold it up to the light. Note the appearance of the spot. What is the difference between the appearance of the water spot and the appearance of the bacon spot? The spot left by the bacon shows the presence of fats. Test cream and butter in the same way. Do these foods contain fats? Test some other foods for the presence of fats. Why was the water spot important?





INVESTIGATE

Test a fresh peanut, an olive, a fresh kernel of corn, and a piece of orange or lemon peel, using the grease-spot test. What results do you get?

Foods Tested for Fats and Oils

Yes

No

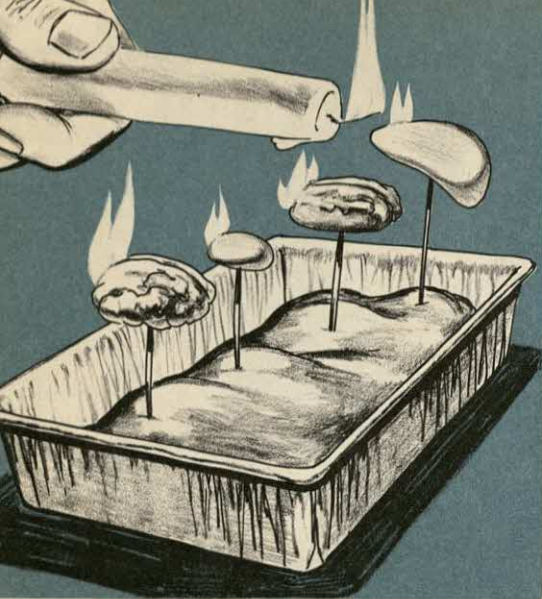
Fats exist in plants in the form of oils. Corn, soybeans, olives, and all nuts are the best sources of oils in plants. Some animals, too, have

oils in their bodies. What animals can you name whose bodies contain oil? Where does cod-liver oil come from?

Examine the fats and oils used for cooking at home. Are these animal products or plant products? Read the labels on cooking fats and oils displayed in the food market. What is the source of these fats and oils?

What Is a Food Calorie?

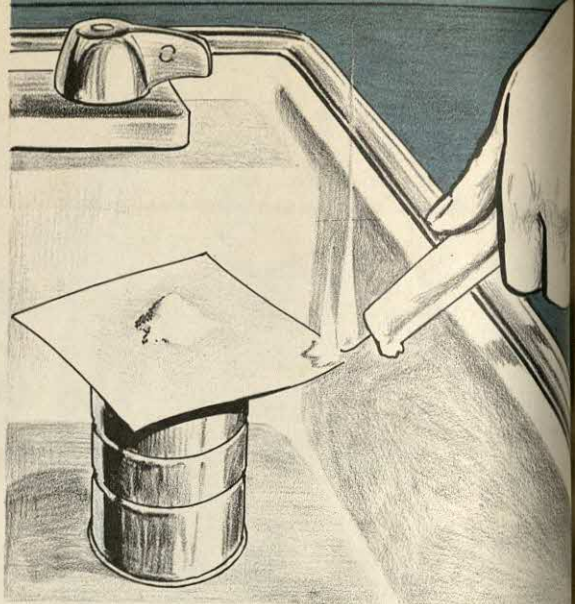
The amount of energy in food is found by burning the food and measuring the heat which is given off. Perhaps you have heard overweight people speaking about the number of "calories" in the food they eat. The heat that is given off during the burning of food is



measured in calories. A food calorie is the amount of heat needed to raise the temperature of a quart of water nearly 2 Fahrenheit degrees. A food calorie, then, is a measure of the amount of heat that can be given off by a certain amount of food. You do not *eat* calories, any more than you eat pounds, ounces, or inches. You eat foods. Some foods can give off a great deal of heat. These are the "high calorie" foods.

TEST

Mount various nuts (a walnut, peanut, pecan, and Brazil nut) on long pins, as shown in the picture. Set the pins upright in a pan which contains a layer of modeling clay. Ignite the nuts with a candle flame. Which nut burns



the longest? Which contains the greatest number of calories?

PREDICT

Place an empty tin can in a sink. Put a piece of stiff paper over the opening of the can, and put a teaspoon of cornstarch on the paper. Ignite the paper. Does cornstarch give off heat? Repeat the activity, using sugar instead of cornstarch. Does sugar give off heat? Is sugar a good energy food? ☐ ☐

Sugar is actually the body's chief source of fuel. About $\frac{3}{5}$ of our normal energy requirement is satisfied by sugar. Why do you think baseball players often munch candy bars?

Most boys and girls between the ages of 10 and 12 need about

AVERAGE DAILY CALORIE REQUIREMENTS

	<i>Age (years)</i>	<i>Weight (pounds)</i>	<i>Height (inches)</i>	<i>Recommended Number of Calories</i>
Children	1-3	27	34	1,300
	4-6	40	43	1,700
	7-9	50	51	2,100
	10-12	79	57	2,500
Boys	13-15	108	64	3,200
	16-20	139	69	3,600
Girls	13-15	108	63	2,600
	16-20	120	64	2,400
Men	25	143	67	3,200
	45	143	67	2,900
	65	143	67	2,600
Women	25	121	62	2,300
	45	121	62	2,100
	65	121	62	1,800

2,500 food calories a day. If you eat foods which supply you with fewer calories than you need, your body will have to burn up some of your stored fats, and you will lose weight. If you eat foods which supply you with more calories than you need, your body will store both the carbohydrates and fats and you will gain weight. Fat is stored under the skin and in different parts of the body, while carbohydrates are sometimes stored in the liver and sometimes changed to fats and stored with the rest of the excess fats.

Between the ages of 16 and 20, girls can get along on a little less than 2,500 calories a day, but boys at the same age need about 3,600 calories a day. Why?

Adjustments must be made to suit the needs of different-sized individuals doing different types of activities. The calorie recommendations given in the chart cannot apply to everyone. The chart is only a standard which helps people to control their weight.

During World War II, many soldiers in prison camps were given a daily amount of food which contained only about 1,000



calories. How were the soldiers able to stay alive during their long stay in the prison camp? What would happen to you if you did not eat enough energy foods for many days in a row?

Climate may affect calorie requirements. In very cold weather, your body sometimes has to burn food just to stay warm. If you lived in the Arctic, you would probably have to increase the amount of fat in your diet. What foods do Eskimos eat? Does the Eskimo's diet have any relation to the heat value of foods? There is a story about a visitor traveling for the first time in Eskimo country, who gave a pound of butter to an Eskimo. Imagine the

visitor's astonishment when the Eskimo took the pound of butter, melted it, and drank it! If you were to drink a pound of butter, you would probably get very sick, because your body is not used to so much fat at one time.

Remember, your body is active even while you are asleep. Your heart continues to pump blood, and various systems of your body continue to work. Your mind works while you sleep.

Foods for Growth and Repair

All of your bodily parts are made up of tissue which is constantly being worn out. This tissue must receive nourishment in order to rebuild itself.

Skin is a familiar example of body tissue. The outermost layer of skin is constantly worn off by rubbing on clothing or other objects. If part of your skin is damaged by a cut, or poison ivy, or an insect bite, the body replaces the damaged tissue.

The lining of your mouth is another example of tissue which gets worn away easily. This wearing away process goes on while you are eating. This tissue, too, must be replaced.

All tissues of your body are in constant need of repair. The materials for building and repairing bodily tissues must come from foods. The foods that build up and repair your body are called proteins. The word protein comes from the Greek word meaning "first." How does this name show the importance of proteins?

Carbohydrates and fats supply energy for the body. If the body is not provided with enough carbohydrates and fats to supply energy, it *can* burn proteins. The main functions of proteins, however, are those of building and repairing. Since you are growing, the foods that contain proteins are very important in your diet.



TEST

Here is a simple way to test a food for proteins. Burn a piece of lean, dried meat. Is the odor of the burning meat pleasant or unpleasant? Burn some hair or feathers. The odor which comes from burning meat, hair, and feathers is a sign of the presence of proteins.



RECORD

Dissolve a few crystals of copper sulfate (available at the drug store) in a glass of water. Add a few drops of this liquid to a glass of household ammonia. You now have a solution which can be used to test foods for the presence of protein. Boil a piece of lean meat in water. Add a few drops of the copper sulfate-ammonia solution to the water in which the meat was boiled. A violet color is a sign of the presence of protein. Test water solutions of other foods (fish, candy, potatoes, sugar, bread) in the same way.

Foods Tested for Proteins

Yes

No

PREDICT

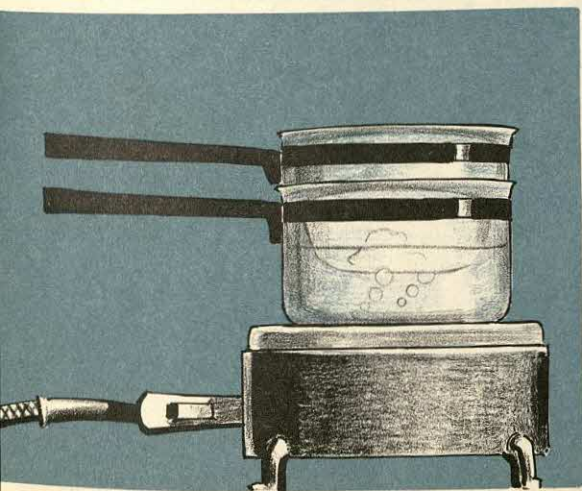
Get a pint of milk that is not homogenized. Pour the milk into a glass bottle. Keep the milk in the refrigerator until the cream and milk separate. Carefully remove all of the cream. Test a few drops of the cream for the presence of fats. Heat the remaining

milk until it is lukewarm. Stir in vinegar, a few drops at a time, until the milk curdles. Pour the curdled milk through a piece of filter paper folded into a funnel. Test the part that remains on the paper for protein (use some of the copper sulfate-ammonia solution).

Boil the liquid that passed

through the paper, and then pour this liquid through a clean filter paper. Again test the part that remains on the paper for protein.

Boil the remaining liquid in the top of a double boiler until the liquid evaporates. Allow the material that is left to cool, and then taste it. How does it taste? What is this material? □ □





Foods which come from animals contain all the proteins your body needs. Is milk an animal food? Vegetable foods do not contain all of the proteins necessary for your body. In areas where animal foods are not included in the daily diet, people become undernourished. Undernourished people suffer from a condition called malnutrition. Malnutrition causes fatigue and weakness.

Breakfast is a very important meal. Why should you include plenty of protein foods in your breakfast? Read the contents listed on boxes of breakfast cereals. Do you find any cereals which have protein content?

ACTIVITY

Make a list of all the foods you have eaten in the past 24 hours. Underline the animal foods.

Minerals

Foods contain material called minerals, which are important for a healthy body. Look at the list of some of the minerals needed by the body.

Have you heard of any of these minerals in their pure form? (Iron, for example, is one of the minerals necessary for nutrition,

but you can't eat iron nails.) The minerals in the foods you eat are in combination with other substances.

One of these combinations is calcium phosphate, which is found in milk. What minerals are present in calcium phosphate? Calcium phosphate helps build strong bones and teeth.

SOME OF THE MINERALS NECESSARY FOR GOOD HEALTH

<i>Minerals</i>	<i>Important Food Sources</i>	
Iron	Beef liver Dry peas and beans Dark-green, leafy vegetables (spinach) Lean meats Egg yolk	
Calcium	Milk Cheese Citrus fruits Eggs Dry peas and beans	
Phosphorus	Lean meat Cheese Milk Fish	Eggs Dry peas and beans Whole-grain cereals
Sodium	Table salt	
Chlorine	Table salt	
Iodine	Iodized salt Salt-water fish	

DISCOVER

Leave some chicken bones in a bottle of vinegar for a few days. Then remove the bones and examine them. Are the bones harder or softer than they were before? Vinegar removes calcium from the bones. What happens to bones that do not get enough calcium phosphate? □ □

Iron is necessary for the red coloring matter in your blood. People who have "weak" blood are usually very pale and are called anemic. Anemics are advised to eat such foods as beef liver, which is a good source of iron.

The chemical name for common table salt is sodium chloride.

What minerals from the list on page 31 are in sodium chloride? Sodium chloride is necessary for the water balance of the body. All body fluids contain sodium chloride. Salts are lost in perspiration, so in very warm climates it is necessary to add salt to the diet.

Iodine is another mineral needed by the body. The small amount of iodine needed by the body is generally found in your daily diet. When iodine is lacking in the diet, a gland in the throat, called the thyroid gland, becomes enlarged. This enlarged gland is called a goiter. Examine a label on a box of table salt. Has iodine been added to the salt?



ACTIVITY

You can test for the presence of minerals by heating a small piece of bread or cheese in a porcelain dish. Keep the dish over a very hot flame until the food is all burned up. What remains in the dish?

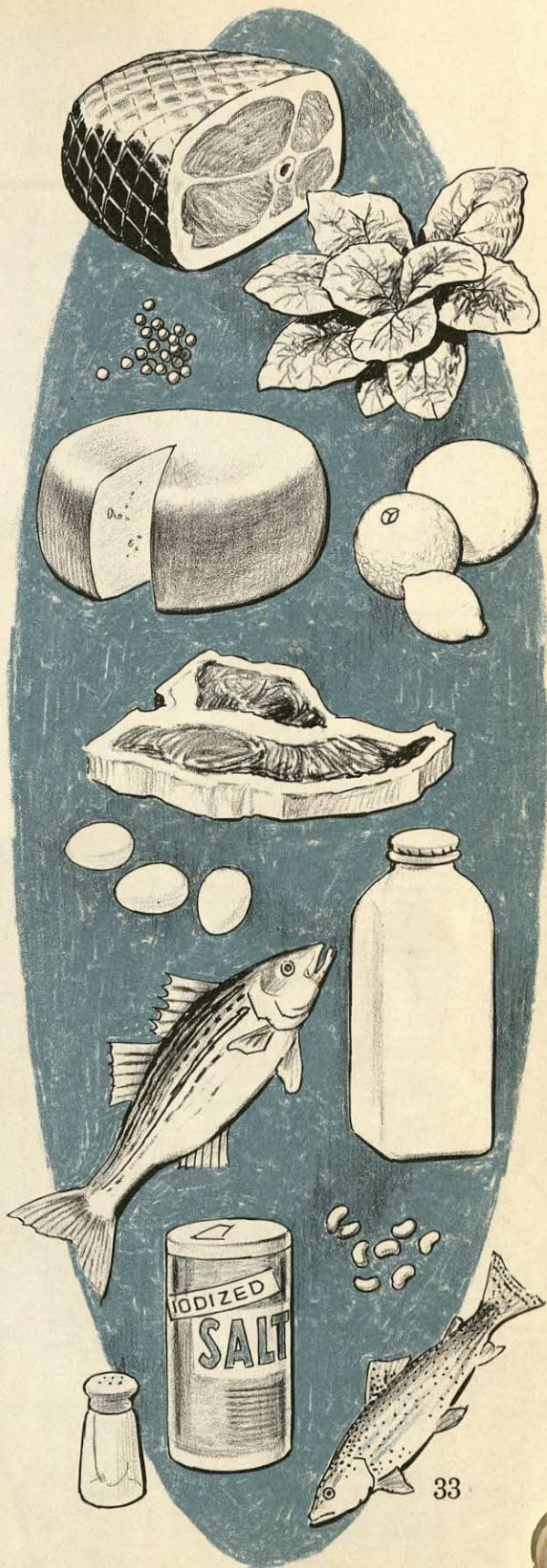
The white ash in the bottom of the dish is the mineral content of the food. What has happened to all the other elements of the bread or cheese during the heating process? Do the minerals in the dish dissolve?

List the foods that are sources of minerals. Check these foods against your diet.

Water

Think of a man lost for weeks in the desert without food or water. Would it be food or water which he would desperately search for first?

Water is neither a food nor a mineral and yet, to stay alive, your body needs lots of water. Most of your body fluids, including blood, are made up of water. About $\frac{9}{10}$ of your blood plasma actually is water. Water acts to dissolve food and waste materials, carrying these materials to and from the body tissues.



Because water is so important, you should always be sure to drink enough water. You need never fear drinking too much water. Why is water called the “life-giving” substance?

About two to five pints of water a day are lost through the kidneys. Some water is also lost through the skin as a result of perspiration. Have you ever noticed how thirsty you get after you have done a hard job that has made you perspire a lot?

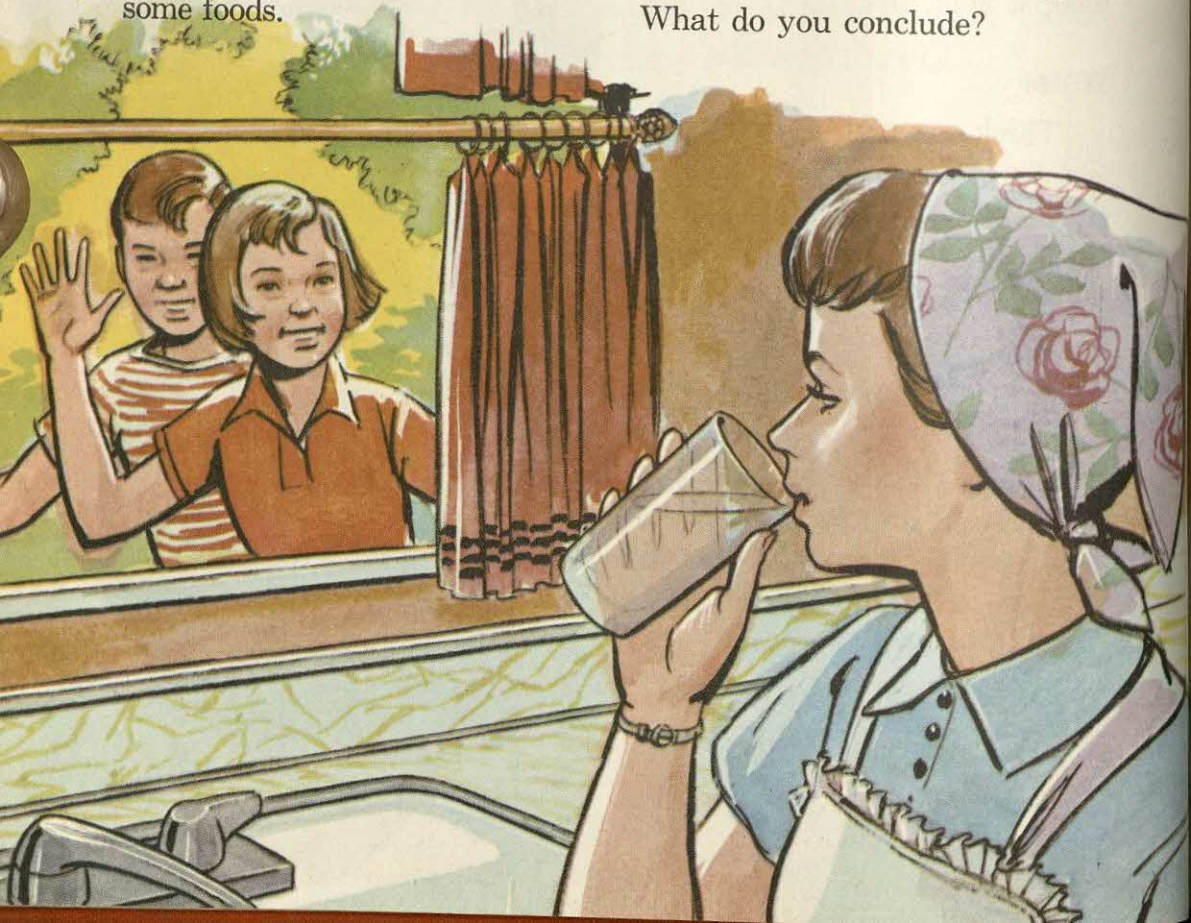
You get most of the water for your body directly through drinking, but water is also supplied by some foods.

COMPARE

Take a ripe, juicy tomato and weigh it. Then heat the tomato until most of the water evaporates from it. Weigh it again. What do you find? Try this test with other fruits and vegetables.

Weigh a slice of apple or potato. Leave the slice of apple or potato in an uncovered container for a few days. Then weigh it again. What do you conclude?

Trace the outline of a slice of fresh apple on a sheet of paper. Leave the apple on the paper for several days. How does the outline compare with the slice of apple? What do you conclude?





Vitamins

Vitamins are not used by the body directly for food and growth. Instead, vitamins regulate bodily activity and growth. Vitamins are complex chemical substances in certain foods that are necessary for health and growth. There are many different vitamins, possibly some still undiscovered. Many of the functions of vitamins are not yet known.

Diseases which result from a lack of a vitamin or vitamins are called vitamin deficiency (deh-FISH-un-see) diseases.

Rickets, a vitamin deficiency disease caused by lack of vitamin D in the diet, weakens the bones.

Lack of vitamin A in the diet

may result in severe disorders of the skin, eyes, and nervous system. Good sources of vitamin A are liver, green and yellow vegetables, tomatoes, butter, and egg yolk. The diets of most people in the United States today are much richer in vitamin A than were the diets of people here one hundred years ago. Americans today tend to be taller, heavier, and healthier than they have been at any time in the past. Improved diet, including foods with vitamin A, is one reason why.

What was once thought to be one vitamin, vitamin B, is now known to be a number of different vitamins. Lack of the B vitamins in the diet results in disease, such as pellagra.

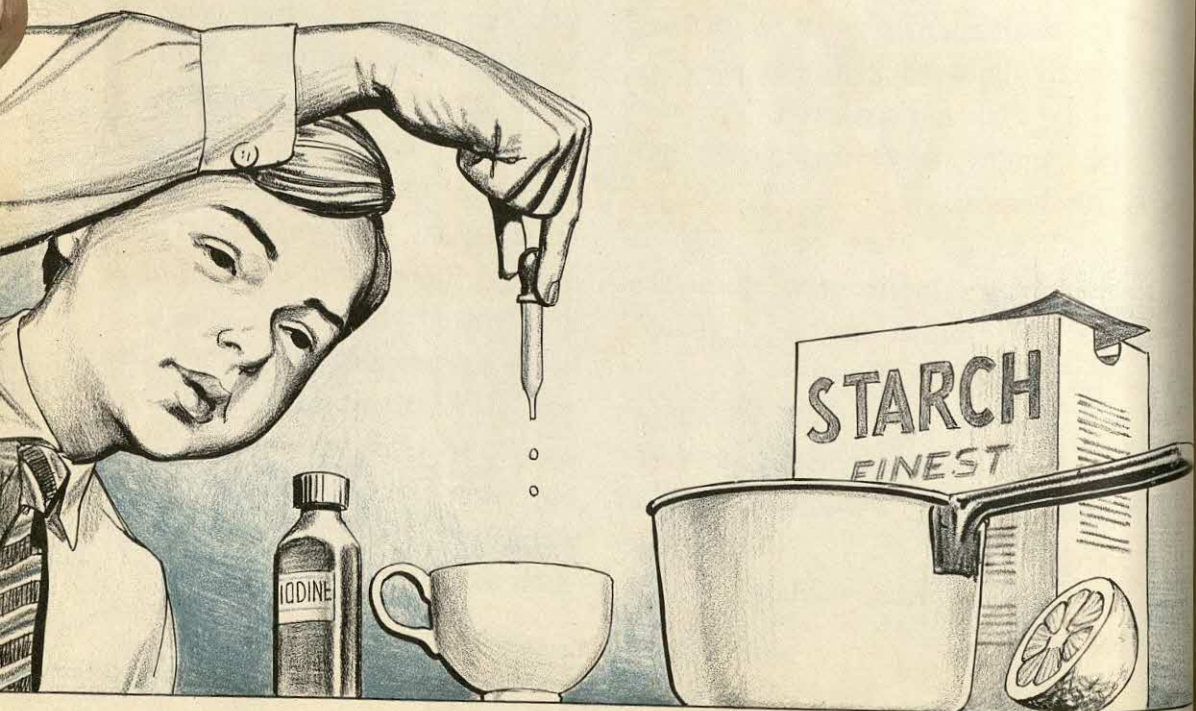
Good sources of the B vitamins are cereals, milk, eggs, vegetables, fish, meat, and poultry. Seafoods are especially rich in one B vitamin. Peanut butter and wheat germ are also excellent sources.

We now know that scurvy, the disease which plagued sailors, is caused by a lack of vitamin C. This vitamin is found in raw fruits, especially citrus fruits (oranges, lemons, grapefruit, limes), tomatoes, cabbage, carrots, potatoes, onions, and turnips. The lack of vitamin C affected the blood of the sick sailors. Why do you think the victims of scurvy always felt weak and tired? Scurvy is no longer a common disease, except in prison camps during wartime

or in very poor communities where people cannot afford fresh fruits and vegetables. The body does not store vitamin C; what is not used is eliminated. What foods, then, should you eat daily?

PREDICT

You can test for the presence of vitamin C in foods. Mix 20 drops of boiled starch and 2 drops of ordinary iodine in one cup of water. What color is this mixture? Drop a piece of citrus fruit into the liquid. What happens to the color of the liquid? This change in color shows that the citrus fruit contains vitamin C. Test bread, eggs, tomatoes, meat, fruit juices, and candy in the same way.



Basic Food Groups

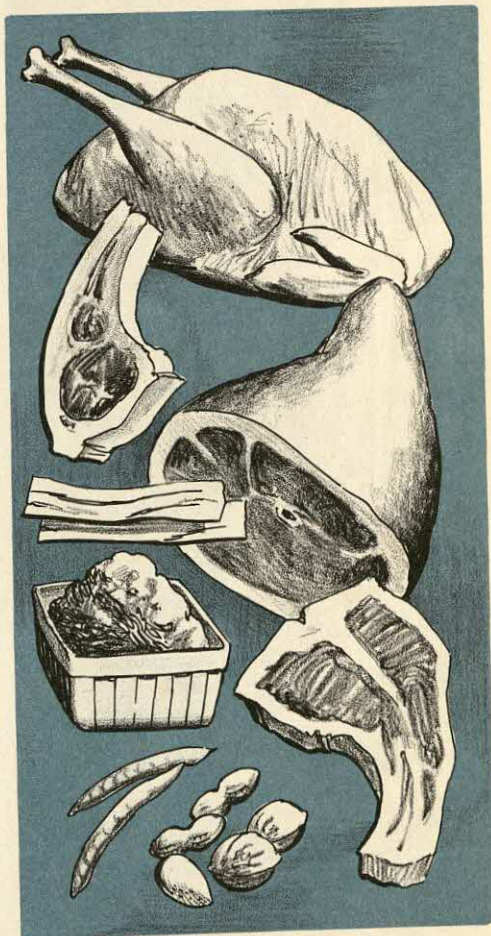
It is very necessary to follow a diet that will provide you with the right amounts of each type of food and with the necessary vitamins and minerals. Such a diet is

called a balanced diet. Do you know why it is called balanced?

One of the best ways to make sure you have a balanced diet is to plan your meals around the four basic food groups.



1. The Milk Group: Drink three or more glasses of milk every day. Foods made with milk, such as ice cream, pudding, some soups, and cheese, may be used to satisfy part of your daily milk requirement.



2. The Meat Group: Two or more servings should be eaten from this group daily, using the beans, peas, and nuts only occasionally as substitutes.

3. The Bread-Cereal Group: Four or more servings of whole grain, enriched, or restored foods from this group are necessary daily.



4. The Vegetable-Fruit Group: Four or more servings daily are necessary. Include one of a citrus fruit and one of a dark-green or deep-yellow vegetable.



Of course, you may sometimes eat more than the recommended number of servings from the four basic food groups. The amounts

of additional foods that you eat should depend on such factors as age, weight, build, activity, and climate.

Planning a Daily Menu

Do you think you could plan your own meals? Perhaps you can make up your own menu. First, study the following menu.

Most boys and girls your age need 2,500 calories a day. Try to make up at least two more daily menus, being sure to provide the

proper number of servings from the four basic food groups. You can easily make up your own menus by simply substituting items in the following menu with foods belonging to the same food group. For example, instead of an orange, you might start the day with half a grapefruit; instead of

A GOOD FOOD PATTERN FOR THE DAY

	<i>Calories</i>
Breakfast	
1 orange	70
whole grain cereal with sugar ($\frac{2}{3}$ cup)	120
toast, butter, and jelly (1 slice)	150
glass of milk	150
Lunch	
tuna fish sandwich	370
green leafy salad	80
stewed fruit ($\frac{1}{2}$ cup)	160
glass of milk	150
Snack	
glass of milk	150
2 plain cookies	120
Dinner	
1 hamburger (large)	245
1 baked potato (medium)	90
carrots ($\frac{1}{2}$ cup)	20
1 roll	115
tomato salad	30
apple pie (1 slice)	330
glass of milk	150
Total calories	2,500



a tuna fish sandwich for lunch, two eggs, a slice of ham, and a roll would serve just as well; instead of carrots, you might select corn; instead of cookies and a glass of milk, ice cream would be an equally pleasant and healthful snack.

Check with the calorie chart that follows to be sure you substitute foods that contain a similar number of calories. Though a chocolate milkshake might provide energy from the same basic

food group as a glass of milk, the difference in the number of calories would be immense. See how close you come to the daily calorie requirement for your age group in the menus you make up.

Study the calorie chart carefully. Try to determine to which basic food group each food item belongs. How does each food item aid your body in providing energy, building and repairing tissue, or regulating body processes?

SELECTED CALORIE CHART

<i>Food</i>	<i>Approximate measure</i>	<i>Calories</i>
Apple, baked	1 med.	120
Apple, raw	1 med.	70
Applesauce	½ cup	175
Apricots, raw	1 med.	20
Asparagus, green, cooked	½ cup or 9 stalks	20
Bacon, broiled or fried	2 slices	95
Banana, fresh	1 med.	85
Beans, white, dry	¾ cup with tomato or molasses	240
Beans, lima, green	½ cup	75
Beans, snap, green, cooked	½ cup	15
Beef, corned, canned	3 slices	180
Beef, hamburger	1 patty	245
Beef, roast	2 slices	255
Beef, steak, broiled	1 piece	245
Beets, cooked	½ cup	35
Beverage, cola-type	¾ cup	80
Bread		
French or Italian	1 slice	60
Rye, light	1 slice	55
White	1 slice	60
Whole wheat	1 slice	20
Broccoli, cooked	½ cup	20
Brussels sprouts, cooked	½ cup	30
Butter	1 tbsp.	100





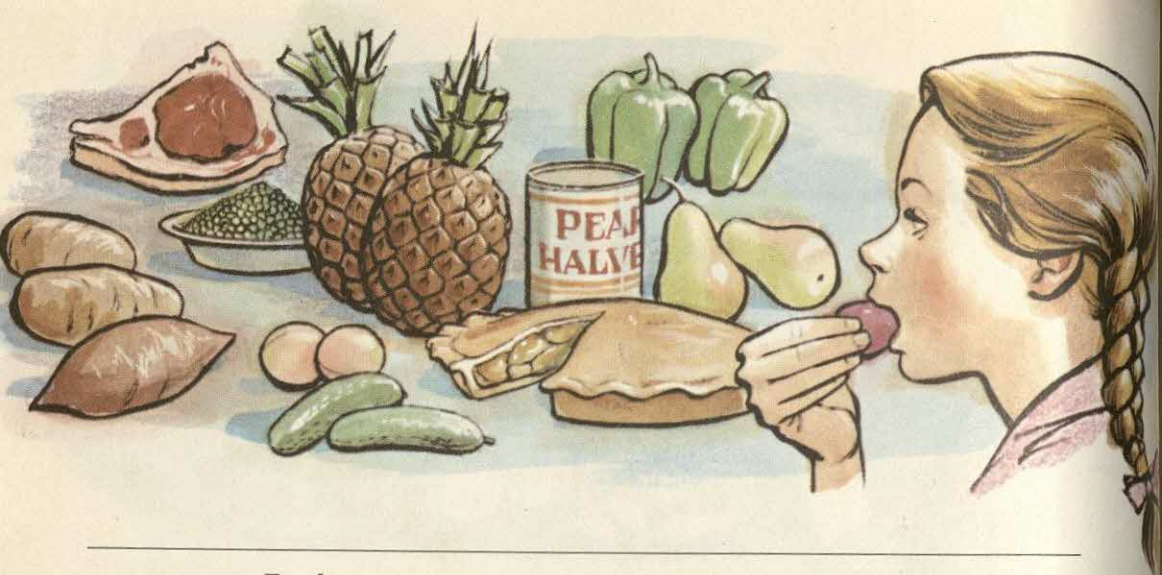
<i>Food</i>	<i>Approximate measure</i>	<i>Calories</i>
Cabbage, cooked	½ cup	20
Cake		
Chocolate layer	2 inch slice	420
Fruit, dark	1 piece	105
Cupcake	1 with icing	160
Layer	2 inch slice	320
Pound	1 slice	130
Candy		
Chocolate bar	1 bar	145
Chocolate bar	1 bar with almonds	265
Chocolate creams	2 pieces	110
Chocolate fudge	1 piece	115
Hard	6 pieces	110
Cantaloupe	½ melon	40
Carrots, cooked or raw	½ cup	20
Cauliflower, cooked	½ cup	15
Celery, raw	1 stalk	5
Cheese, American	1 cube, 1 ⅛ in.	115
Cheese, cottage	2 tbsp.	25
Cheese, cream	1 tbsp.	55
Cheesecake	1 slice	400
Chicken, broiled	½ small chicken	185
Chicken, fried	1 leg (thigh and drumstick)	245
Chocolate syrup	2 tbsp.	80
Cocoa, beverage	¾ cup	175
Cole slaw	½ cup	50

<i>Food</i>	<i>Approximate measure</i>	<i>Calories</i>
Gelatin dessert	½ cup	80
Gingerbread	1 slice	180
Grapefruit, fresh	½ med.	50
Grapes, fresh	1 cup	70
Greens, spinach	½ cup	15
Haddock, fried	1 fillet	135
Ham, smoked, cooked	2 slices	290
Ham, luncheon meat	1 slice	170
Ice, orange	½ cup	140
Ice cream	1 container	130
Ice cream, vanilla	1 scoop	200
Ice cream soda, chocolate	1 fountain-size	255
Jams, marmalades	1 tbsp.	55
Jellies	1 tbsp.	50
Lamb chops, broiled	1 shoulder chop	405
Lemonade	1 cup	110
Lettuce	1 head	70
Liver, fried		
Beef	1 slice	120
Calf	1 slice	230
Chicken	3 med.	235
Pork	1 slice	225





<i>Food</i>	<i>Approximate measure</i>	<i>Calories</i>
Macaroni, cooked	$\frac{3}{4}$ cup	115
Macaroni and cheese, baked	$\frac{3}{4}$ cup	350
Margarine	1 tbsp.	100
Meatloaf, beef, baked	1 slice	240
Milk		
Chocolate-flavored	1 cup	190
Whole	1 cup	165
Malted, beverage	1 fountain-size glass	350
Milkshake, chocolate	1 fountain-size glass	420
Noodles, egg	$\frac{3}{4}$ cup	150
Nuts		
Cashews, roasted	$\frac{1}{4}$ cup	195
Peanuts, roasted	20 nuts	90
Walnuts, halves	8 med.	100
Oatmeal or rolled oats	$\frac{2}{3}$ cup	100
Onions, raw	1 onion	50
Orange, fresh	1 orange	70
Orange juice	$\frac{1}{2}$ cup or 1 small glass	60
Pancakes, wheat	1 griddlecake	60
Peaches, canned	2 med. halves	90
Peaches, fresh	1 med.	50
Peanut butter	1 tbsp.	90



<i>Food</i>	<i>Approximate measure</i>	<i>Calories</i>
Pears, canned	2 med. halves	130
Pears, fresh	1 med.	95
Peas, green, cooked	$\frac{1}{2}$ cup	55
Peppers, green, sweet	$\frac{1}{4}$ cup, diced	5
Peppers, green, stuffed	1 med. with meat stuffing	200
Perch, ocean, fried	4 x 3 x $\frac{1}{2}$ in.	195
Pickles, dill	1 large pickle	15
Pickles, sweet	1 pickle	20
Pie.		
Apple	4-inch sector	330
Cherry	4-inch sector	340
Custard	4-inch sector	265
Lemon meringue	4-inch sector	300
Pumpkin	4-inch sector	265
Pineapple, canned	2 small slices	95
Pineapple, fresh	$\frac{1}{2}$ cup, diced	35
Pizza pie (cheese)	5 $\frac{1}{2}$ -inch sector	180
Plums, fresh	1 plum	30
Popcorn, popped, buttered	1 cup	90
Pork chop	1 chop	260
Pork, roast	2 slices	310
Potatoes		
White, baked	1 med.	90
French fried	10 pieces	155
Mashed	$\frac{1}{2}$ cup (milk and butter added)	115
Chips	10 med.	110
Sweet, baked	1 med.	155
Sweet, candied	$\frac{1}{2}$ potato	150

<i>Food</i>	<i>Approximate measure</i>	<i>Calories</i>
Poultry potpie	1 individual pie	485
Pretzels	5 small sticks	20
Prunes, dried, cooked	5 med.	160
Pudding, chocolate	$\frac{1}{2}$ cup	190
Pudding, rice with raisins	$\frac{1}{2}$ cup	300
Pudding, tapioca	$\frac{1}{2}$ cup	140
Rice, boiled	$\frac{3}{4}$ cup	150
Rice, puffed	1 cup	55
Roll, hard, white	1 round roll	160
Roll, soft, white	1 roll	115
Roll, sweet	1 roll	135
Salads		
Chicken	$\frac{1}{2}$ cup with mayonnaise	280
Egg	$\frac{1}{2}$ cup with mayonnaise	190
Fresh fruit	$\frac{1}{2}$ cup with French dressing	130
Lettuce	$\frac{1}{4}$ head with French dressing	80
Potato	$\frac{1}{2}$ cup with mayonnaise	185
Tuna fish	$\frac{1}{2}$ cup with mayonnaise	250
Salad dressing, French	1 tbsp.	60
Salad dressing, mayonnaise	1 tbsp.	110
Salmon, canned	$\frac{1}{2}$ cup	120
Salmon, boiled or baked	1 steak	200
Sardines, canned	5 pieces	120
Sauerkraut	$\frac{1}{2}$ cup	15



<i>Food</i>	<i>Approximate measure</i>	<i>Calories</i>
Sausage		
Bologna	3 slices	170
Liverwurst	3 slices	150
Pork	3 small patties	170
Salami	1 slice	135
Sherbet	½ cup	120
Shrimp, canned	½ cup	110
Syrup	1 tbsp.	55
Soup, canned		
Bean	1 cup	190
Chicken-noodle	1 cup	85
Clam chowder	1 cup	85
Consomme	1 cup	10
Cream vegetable	1 cup	200
Tomato	1 cup	90
Vegetable	1 cup	80
Spaghetti, cooked	¾ cup	115
Spaghetti, with meat sauce	¾ cup	215
Squash, summer	½ cup	20
Squash, winter	½ cup	50
Stew, beef and vegetable	¾ cup	140
Strawberries, fresh	½ cup	30
Sugar, granulated	1 tbsp.	50
Tangerine, fresh	1 med.	40
Tomato, raw	1 med.	30
Tomato catsup	1 tbsp.	15
Tomato juice	½ cup or 1 small glass	25
Veal, roast	2 slices	305
Veal cutlet, broiled	1 med. cutlet	185
Veal cutlet, breaded, fried	2 slices	315
Waffles	1 waffle	240
Watermelon	1 wedge, 4 x 8 in.	120
Wheat flakes	1 cup	100
Wheat flour	1 cup	400
White sauce	¼ cup	110

The Digestive System and its Organs

Food for Life and Growth

Your living and growing body needs oxygen, but you cannot live on oxygen alone. Your body must have food to supply the energy it needs to grow, to repair tissue that has become worn out or injured, and to perform other tasks.

An apple, a slice of roast beef, or a piece of chocolate cake cannot be used by your body as it is. The food must be broken down to tiny particles that can pass into the tissues and cells of which your body is composed.

Your body changes the food you eat to a soft mass, and then to a liquid containing very tiny particles. The process by which your body changes the food you eat to a form in which it can be used is the process of digestion.

The main organs of digestion form a long passageway through your body. This passageway, through which the food travels, is called the alimentary (*al-i-MEN-ta-ree*) canal.

The Mouth

As soon as the first bite of food is taken into your mouth, the food

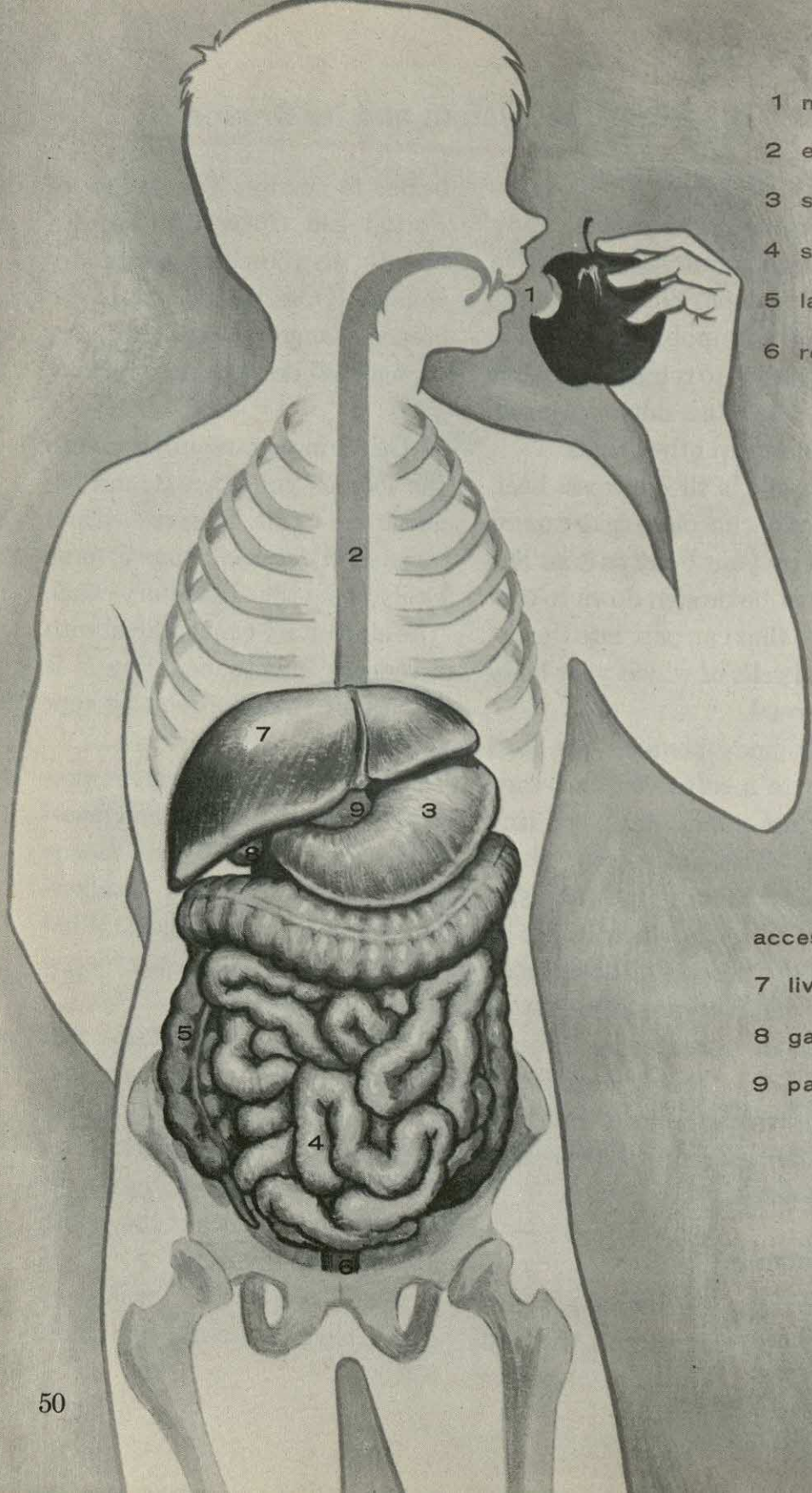
begins to change. Take a bite of white bread. Chew it for about a minute. As you chew, notice any changes. Does the texture of the bread change? Does its flavor change? Where does digestion begin?

Saliva in your mouth moistens the food as you chew it, and begins to change it. The crushed and moistened food can move more easily along the alimentary canal. The alimentary canal is lined with a mucous membrane. Why is it important that the food be kept moist?

Your tongue has a very important part in the tasting and digestion of foods. Hold your tongue with a clean tissue or handkerchief and try to swallow. What happens? How does your tongue help you swallow?

The tongue is a muscle that moves the food around in your mouth, to aid the teeth in their tearing and grinding action. After the food is chewed well, the tongue pushes it to the back of the mouth and into the throat.

Your teeth cut, crush, and grind food. A tooth has three



1 mouth

2 esophagus

3 stomach

4 small intestine

5 large intestine

6 rectum

accessory organs

7 liver

8 gall bladder

9 pancreas

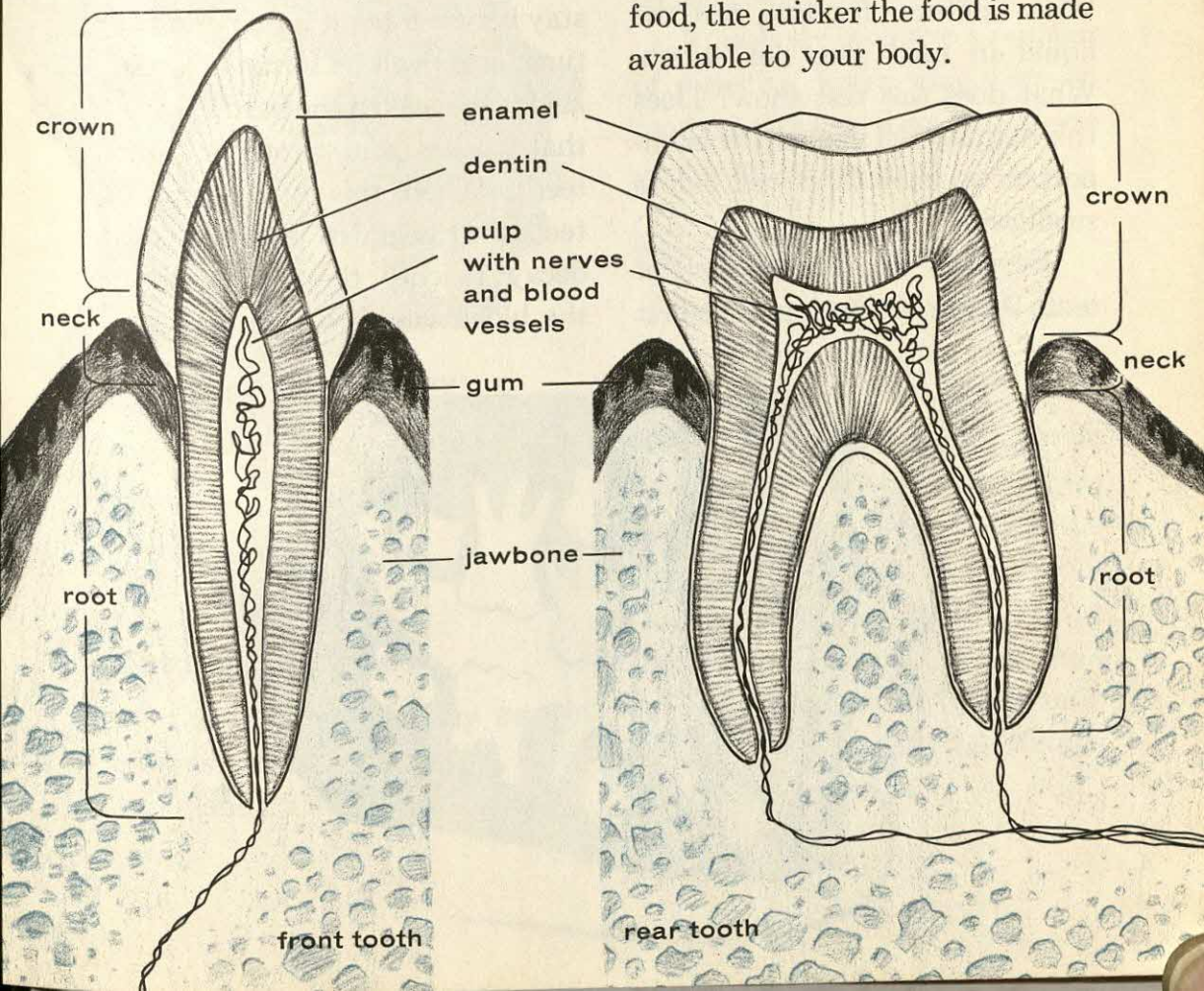
parts, as you can see in the diagram. The part that you can see when you look at your teeth is the crown or top. The remaining parts of the tooth are covered by the pink tissue called the gum. The middle part of the tooth that is right at the gum is often called the neck, because it connects the crown with the root. The root is deep in the gum, and fits into the jawbone.

The teeth are hard, like bones, but a tooth will not grow together when it is broken, as a bone will.

The teeth are covered with enamel, which is the hardest material found in the body.

If you were to cut through a tooth, you would see that a tooth is made of three different layers of material. Hard, shiny enamel forms the outside layer. Right under the enamel is bone-like material called dentin (DEN-tin). At the very center, under the dentin, is a very important part called the pulp. There are many tiny blood vessels and nerves in the pulp.

The longer you chew your food, the quicker the food is made available to your body.



QUESTION

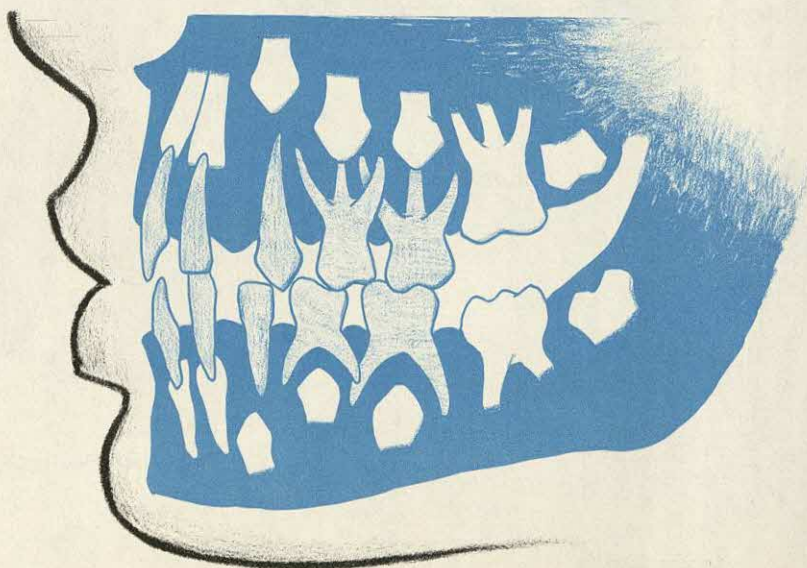
Get a raw potato, 2 drinking glasses half full of water, 2 empty glasses, a potato grater, and tincture of iodine. Peel the potato, cut it in half, and grate one half as finely as possible. Put the grated potato in one of the glasses of water. Cut the other half of the potato into 4 or 5 pieces, and drop these into the second glass of water. Shake both glasses vigorously for a few minutes. Then pour the same amount of liquid from each glass into the two empty glasses. With tincture of iodine, test the liquid in each glass for starch. What does this test show? Does this activity tell you why it is important to chew food well before swallowing? ☐ ☐

Everyone develops two sets of teeth during his lifetime. The first

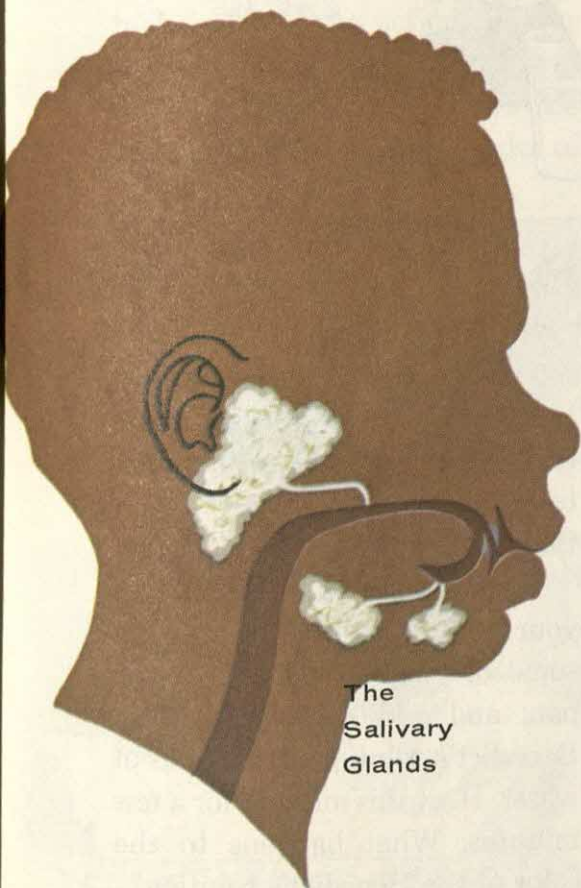
set are temporary teeth. We generally call them baby teeth, and there are 20 of them altogether. Do you still have your baby teeth?

The second set are permanent teeth. As the second teeth begin to grow, they push against the baby teeth until finally the baby teeth fall out. There are 32 permanent teeth that develop. These teeth are stronger than the temporary teeth.

Why is it important to take care of your teeth and brush them regularly? When particles of food stay between teeth for a period of time, acids will be formed. These acids can weaken the hard enamel that covers and protects your teeth. When this happens, the teeth will begin to decay. If the decay reaches the pulp, where the blood vessels and nerves are



found, it will cause a great deal of pain. Have you ever had a toothache? Why should you visit your dentist regularly?



The Salivary Glands

Saliva is supplied by certain organs called salivary (SAL-i-var-ee) glands. There are other glands

in the body that give off other juices. The juices that glands give off assist the systems of the body in carrying out their work.

There are three sets of salivary glands in your mouth. As you can see in the diagram, one set is in front of and just below your ears. The other two sets are located under your tongue, and at the back part of your lower jaw.

These glands make saliva. Saliva is a digestive juice which is carried into your mouth through tiny tubes, called ducts, on each side of your tongue.

Your body produces a number of digestive juices which act on foods and change them into a form which can be digested.

EXPLORE

Take a piece of bread and place it in your mouth. Mix the bread with saliva. Hold the bread in your mouth for a few minutes. What do you taste? Do you know where this taste comes from? Repeat the same activity with a drink of milk or a piece of meat. Does the same sweet taste develop? Does milk or meat have starch? How would you prove that saliva can change starch to sugar? ☐ ☐



OBSERVE

You will need a boiled potato, a small cooking pan, Benedict's solution, water, a measuring cup, and an eye dropper. In the presence of sugar, Benedict's solution turns orange.

Chew a piece of the potato for about a minute without swallowing. Place the chewed potato in the pan, add 2 tablespoons of Benedict's solution and $\frac{1}{2}$ cup of water, and boil the mixture. What happens to the color of the Benedict's solution?

Wash the pan thoroughly. Break some of the unchewed potato into small pieces and drop them into the pan. Add 2 table-

spoons of Benedict's solution and $\frac{1}{2}$ cup of water. Heat this mixture for a few minutes. What happens to the color of the Benedict's solution this time?

Wash the pan again. Rinse your mouth with water. Place some of your own saliva in the pan, and add 2 tablespoons of Benedict's solution and $\frac{1}{2}$ cup of water. Heat this mixture for a few minutes. What happens to the color of the Benedict's solution?

Does the unchewed potato contain sugar? Does your saliva contain sugar? An unchewed potato contains starch. What happens to the starch in the potato when it is mixed with saliva? ☐ ☐

The release of saliva into the mouth is controlled by the brain. Even as you are reading about food in this unit on nutrition, saliva is being produced by your salivary glands. Does the thought of a hamburger and a glass of milk increase the action of your salivary glands? Some digestive glands begin to function at the very thought of food. The odor of

freshly baked bread or cooking meat, or the sight of appetizing food also stimulates the action of these glands.

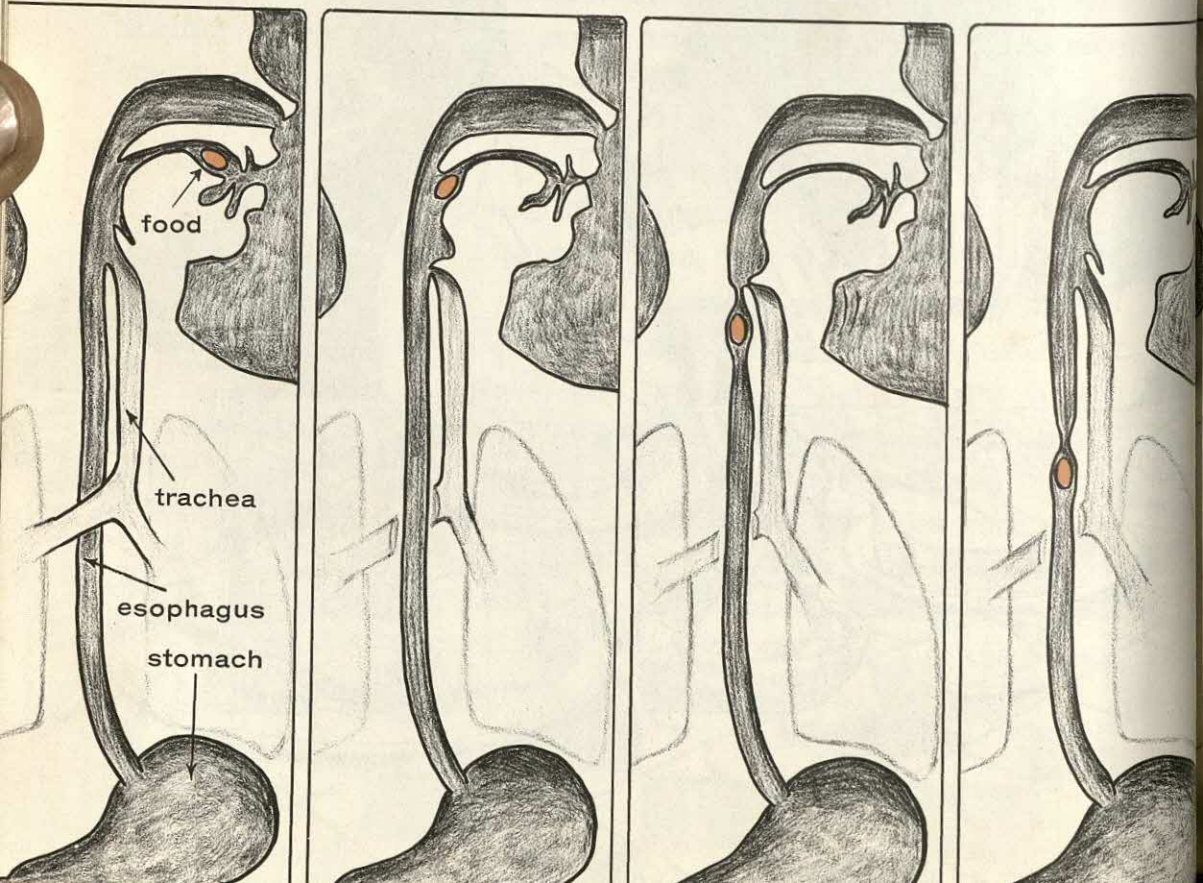
Notice that the entire inner surface of your mouth is moist. This surface contains numerous glands that produce a moist, slippery liquid called mucus (MYOO-kuss). How do you suppose mucus helps digestion?



The Pharynx and Esophagus

Food which is swallowed passes through two structures which do not produce digestive juices—the pharynx (FAIR-ingks), behind the mouth cavity, and the esophagus (ee-SOF-a-gus), the long muscular tube leading to the stomach. Like the mouth, these areas are lined with many mucous glands which function to keep the food's pathway wet and slippery. Liquids pass very quickly down the esophagus into the stomach, while solid foods are moved down the muscle-lined tube by a special “wave” action known as peristal-

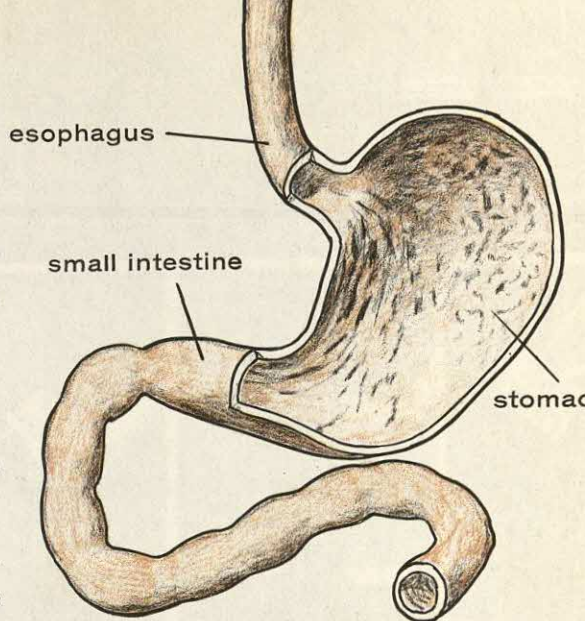
sis (*pehr-ih-STAHL-sis*). The muscles in the wall of the tube relax in front of the food, while the muscles behind the swallowed food contract. Thus, the food mass is squeezed along the digestive tract in a rhythmic way. The wave-like action of peristalsis allows you to eat and drink even though your head at times may hang lower than your stomach. When such animals as the swan and the giraffe eat, their heads are often lower than their stomachs. In these animals, food sometimes travels upward to the stomach, aided by peristalsis.



What Happens to Food in the Stomach?

The stomach, often described as a muscular sack lined with a mucous membrane, is a swollen bag with a small opening at each end. Unlike the mouth, the stomach has no way of grinding food.

Glands in the lining of the stomach manufacture an acid, called hydrochloric acid, which aids digestion. Food entering the stomach is acted upon by an acid "bath" together with the churning action caused by the moving stomach muscles.

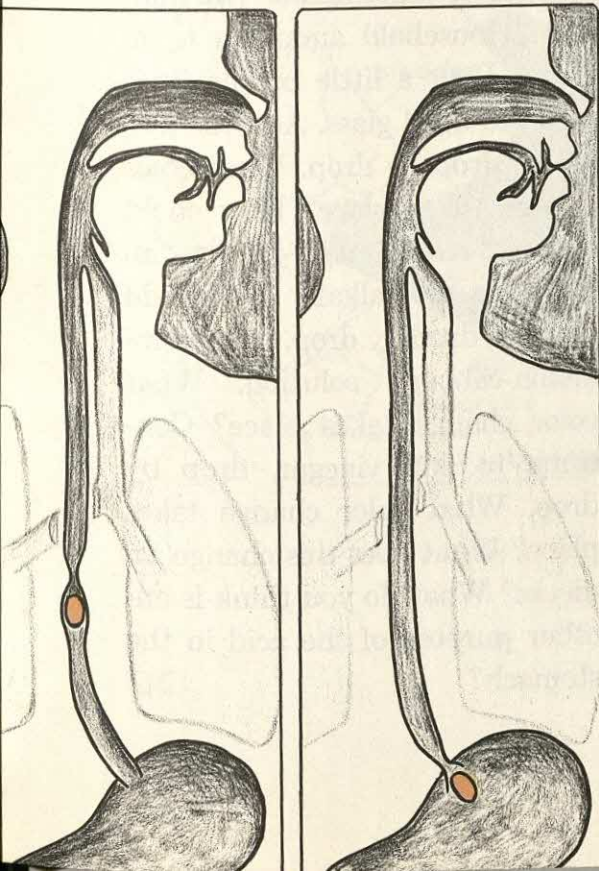


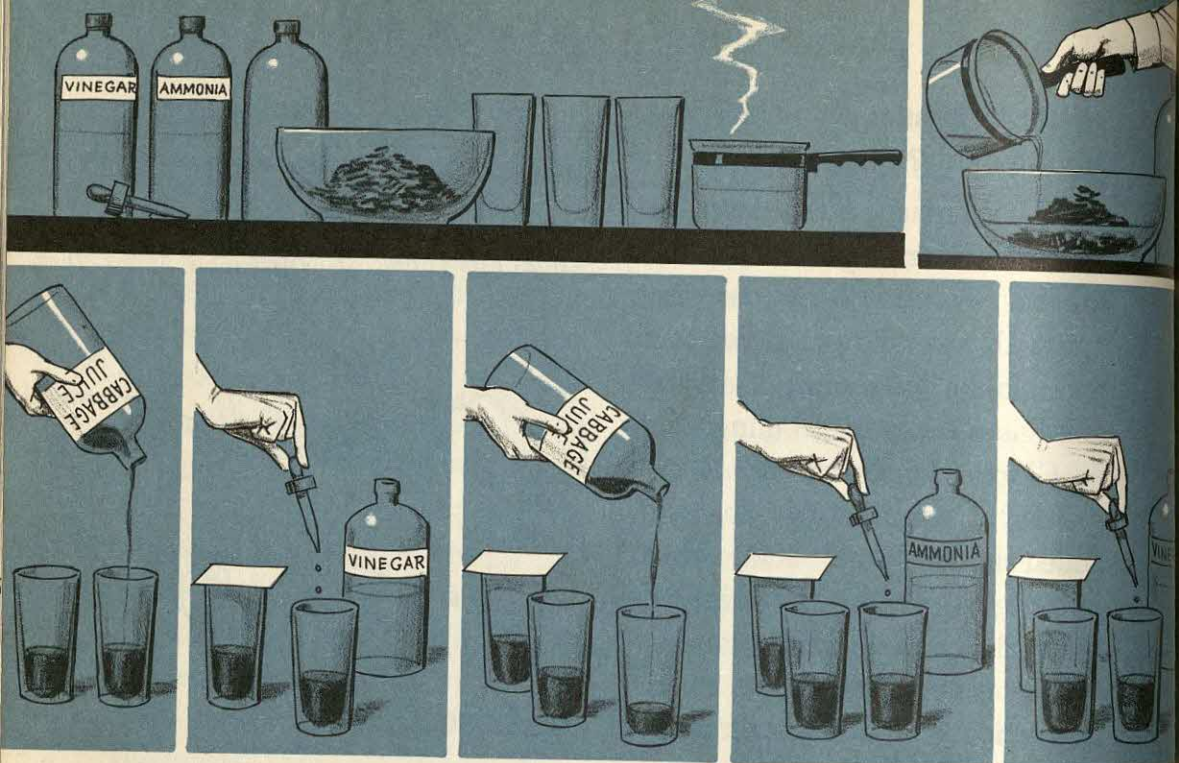
INVESTIGATE

You will need red cabbage, a bowl, 1 cup boiling water, a wooden spoon, a clean, empty bottle, a medicine dropper, white vinegar, and household ammonia.

Shred 2 or 3 cabbage leaves and place the shredded cabbage in the bowl. Pour the boiling water over the shredded cabbage and let it stand for about one hour. Use the spoon to squeeze as much juice as possible from the cabbage.

What color is the juice from the red cabbage? Pour this colored liquid into the bottle. You can use the cabbage juice to test foods for the presence of acid. White vinegar is a weak acid. You can use this acid for your test.





Pour a little cabbage juice into 2 clean glasses. Cover one glass and leave it undisturbed. This is your control. Add vinegar, drop by drop, to the other glass. Use a medicine dropper. Observe.

What color change takes place? Compare the colors of the control and the acid cabbage juice. Vinegar turns the purple juice to red. Any food that turns the purple juice to red contains acid. Therefore, you can use the purple juice as an indicator of acid. Test several food solutions to see if acid is present. What do you think is one purpose of the acid produced in the stomach?

Some foods you eat contain substances called alkalis (AL-kuh-lyz). Household ammonia is an alkali. Pour a little purple juice into the third glass. Add the ammonia drop by drop. What color change takes place? How could you use red-cabbage juice as an indicator for alkali? Now add vinegar, drop by drop, to the ammonia-cabbage solution. What color change takes place? Continue to add vinegar, drop by drop. What color change takes place? What does this change indicate? What do you think is another purpose of the acid in the stomach?

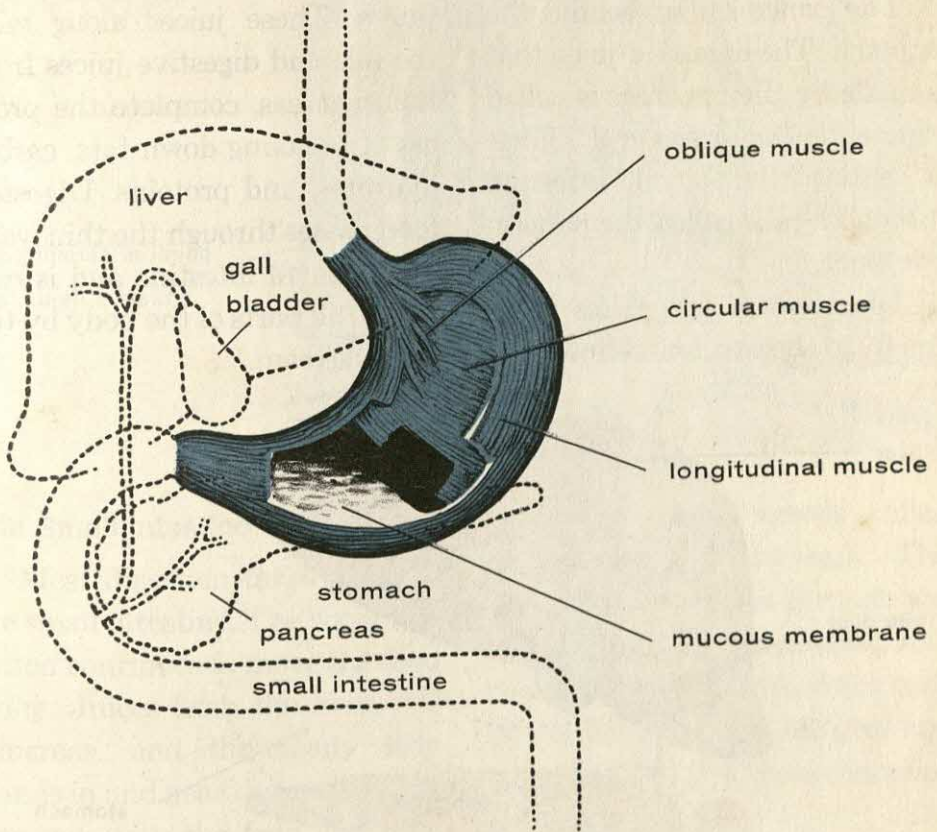


Glands in the stomach aid in the digestion of protein foods. Starches continue to be broken down in the stomach. Where does the digestion of starches begin?

The wall of the stomach is composed of three layers of muscle and an inner, mucous membrane lining. Each layer moves in a different direction. Some muscles squeeze the stomach inward. Muscles of the inner layer run at

an angle. The muscle layers move at the same time. Thus the stomach mixes its contents.

The movements of the stomach, together with the secretions of the glands, change most of the food in the stomach into a thick liquid called chyme (KYME). Squirts of chyme leave the stomach and enter the small intestine, a part of the digestive tube below the stomach.



What Happens to Food After It Leaves the Stomach?

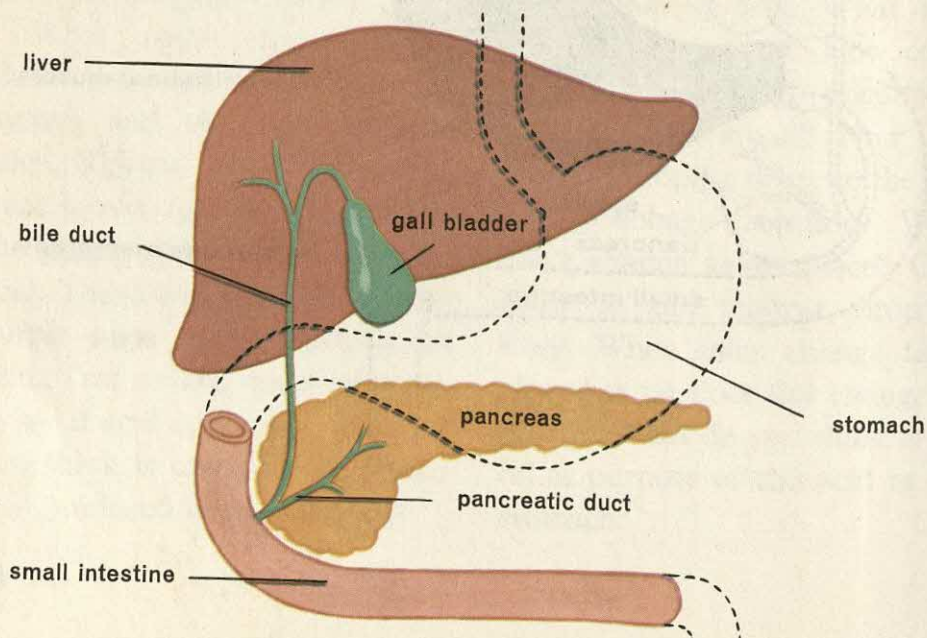
The passage of liquid-food from the stomach into the small intestine causes the pancreas (PAN-kree-us), the second largest gland in the body, to secrete a digestive juice which mixes with the partly digested food. The digestive juice of the pancreas helps to split up carbohydrates, fats, and proteins.

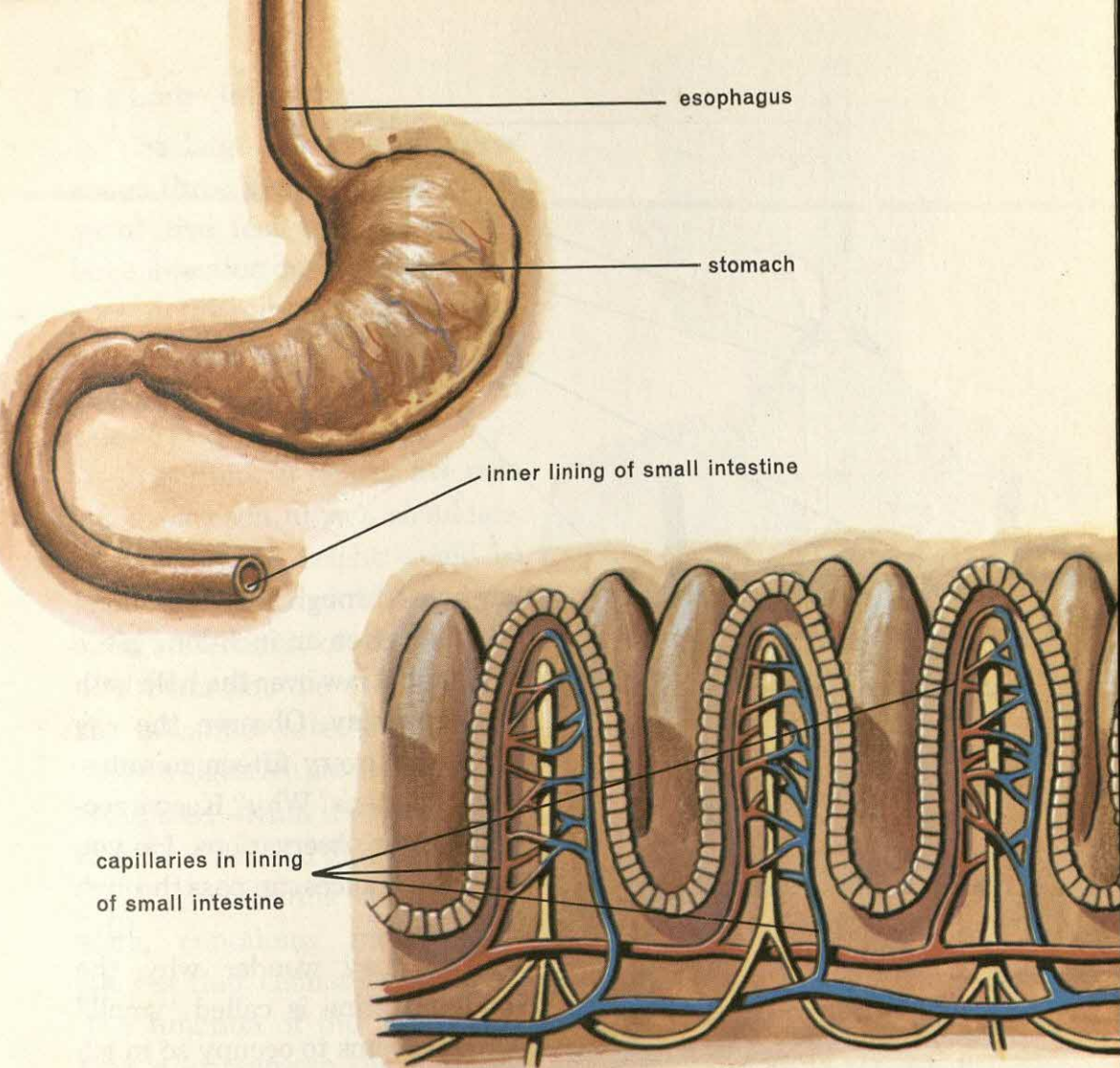
The pancreas lies behind the stomach. The digestive juice that is made by the pancreas is called pancreatic (*pan-kree-AT-ik*) juice. It enters the small intestine through a tube called the pancreatic duct.

Digestion of fats takes place chiefly in the small intestine. Two

organs, the liver and the gall bladder, aid in digesting fats. The liver is the largest gland in the body. It manufactures a fluid called bile. Bile helps prepare fats for digestion. Bile is stored in the gall bladder. It is used when necessary to help digest food. It divides the very large fat drops in the partly digested food into very fine droplets.

Glands in the inner lining of the small intestine make digestive juices. These juices along with the bile and digestive juices from the pancreas, complete the process of breaking down fats, carbohydrates, and proteins. Digested food passes through the thin walls of the small intestine and is carried to all parts of the body by the blood stream.





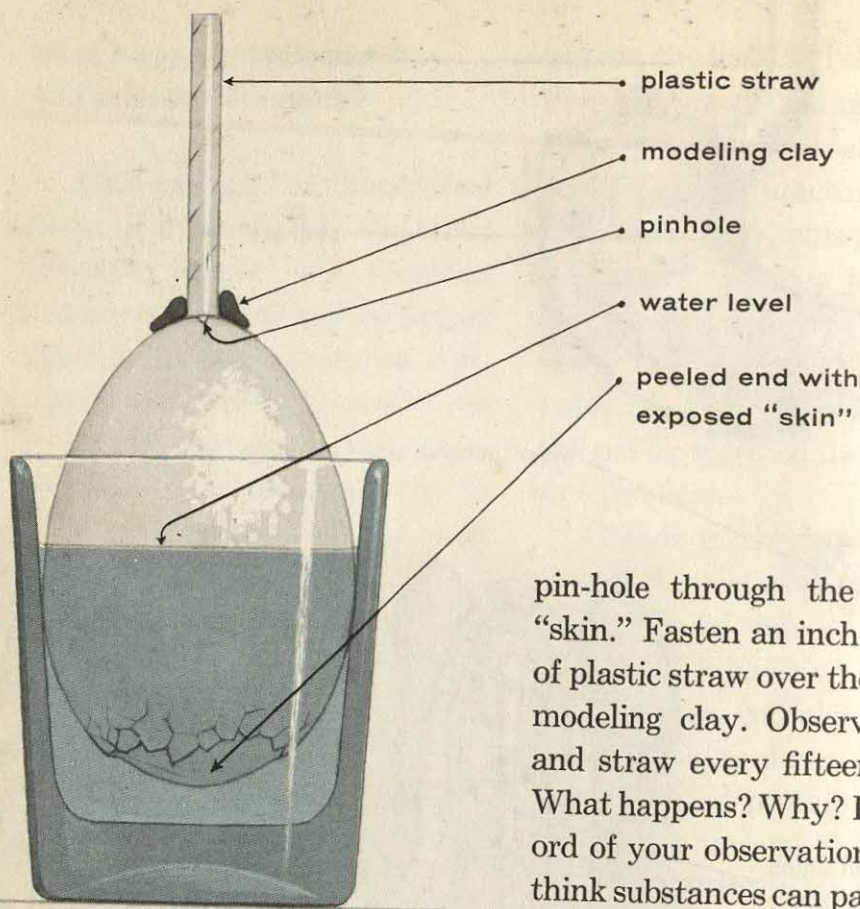
The Small Intestine

Most digestion takes place in the small intestine. The wave-like action continues to move the food along. Juices from the liver, the pancreas, and the many tiny glands in and near the small intestine mix with the food and help to digest it further.

The small intestine is lined

with tiny blood vessels called capillaries (KAP-i-ler-eez). The digested food passes through the thin walls of the capillaries, and the blood carries it to all the cells of the body. As you are growing, the cells of your body are increasing in number.

How can the food pass through the walls of the capillaries?



pin-hole through the shell and "skin." Fasten an inch-long piece of plastic straw over the hole with modeling clay. Observe the egg and straw every fifteen minutes. What happens? Why? Keep a record of your observations. Do you think substances can pass through thin tissue? ☐ ☐

You may wonder why the small intestine is called "small" when it seems to occupy so much of the abdominal cavity. As the small intestine extends from the stomach, the tube becomes narrower. It is then only about one inch across the center. This is why it is called small. The length of the small intestine, in an adult, is usually more than twenty feet. Look at the diagram on page 63. Is the large intestine narrower or wider than the small intestine?

INVESTIGATE

Take a small juice glass in which an egg will fit without touching the bottom. Peel away some of the shell from the wider end of a fresh egg. Do not break the thin "skin" inside.

Put enough water in the glass to come half-way up the side of the egg. Place the egg in the glass, with the peeled end down.

At the top of the egg, make a

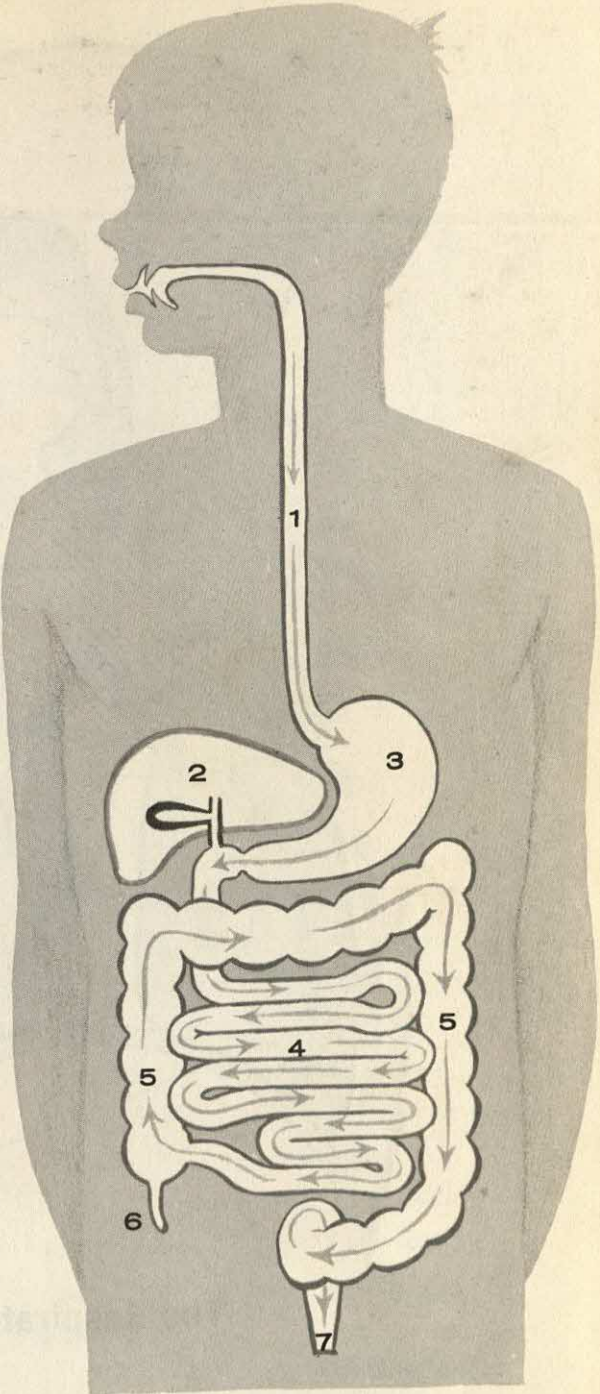
The Large Intestine

The large intestine measures about three inches across, and is about five feet long. Trace the large intestine on the diagram. It goes up the right side of the abdomen, crosses under the liver and stomach, then goes down the left side to end in the rectum.

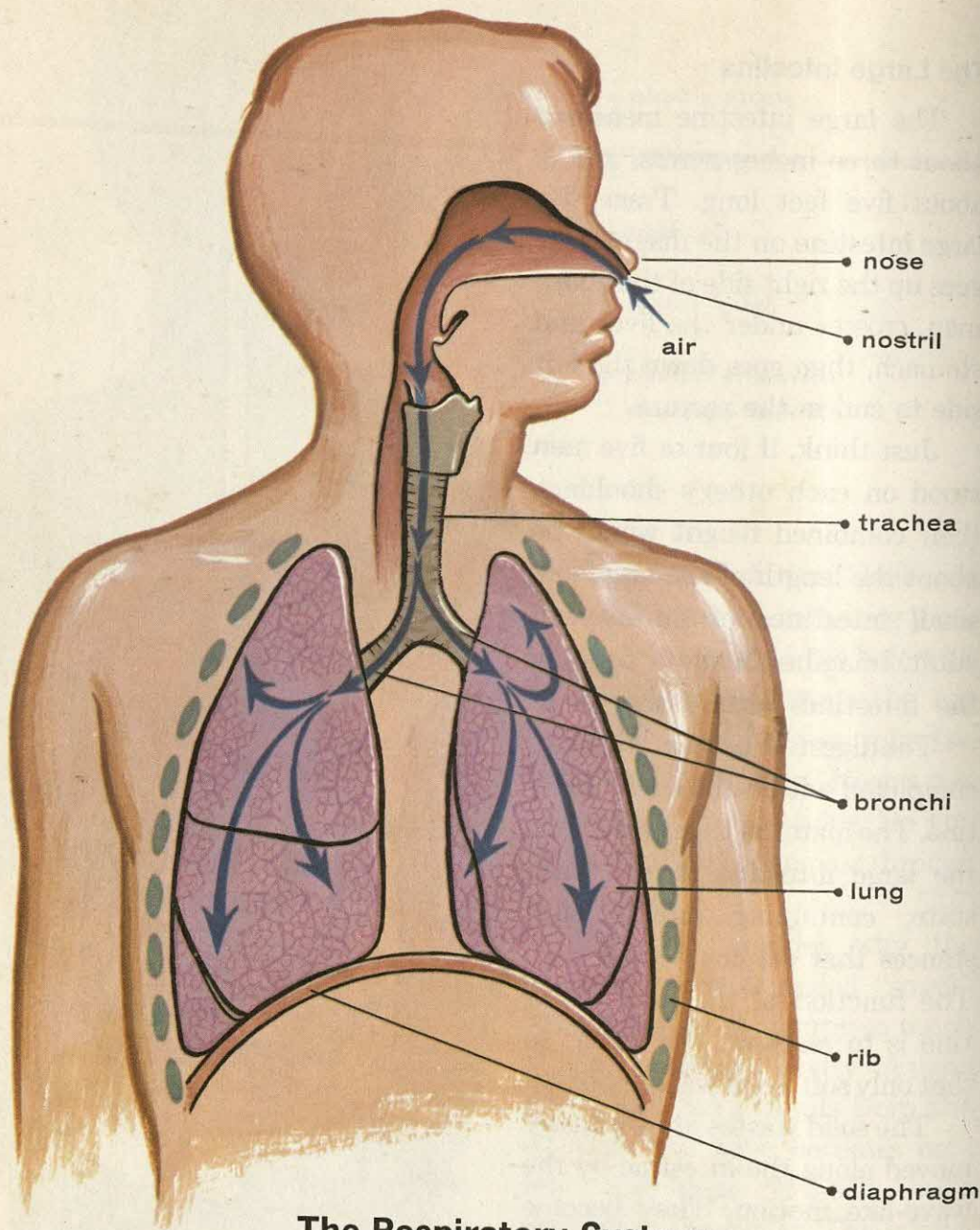
Just think, if four or five men stood on each other's shoulders, their combined height would be about the length of the large and small intestines of an average adult. Imagine the work done by the intestines after every meal!

The digestive process is usually completed within the small intestine. The material that passes into the large intestine is in a fluid state, containing mostly substances that cannot be digested. The function of the large intestine is to reabsorb the water, so that only soft, solid wastes remain.

The solid wastes are gradually moved along the intestine by the wave-like motion. They become more solid, and finally reach a muscular bag, called the rectum, at the end of the large intestine. It is from the rectum that the body rids itself of all the solid waste materials.



- 1 esophagus
- 2 liver
- 3 stomach
- 4 small intestine
- 5 large intestine
- 6 appendix
- 7 rectum



The Respiratory System

Oxygen for Life and Growth

One of the most important elements in your body is oxygen. You cannot live without it. The

air you breathe is your body's most important source of oxygen. Breathe in. How does the air enter your body? Where does it go?

Put your finger on the diagram and follow the path taken by the air as it enters the body.

The system by which you inhale oxygen from the air and exhale carbon dioxide is the respiratory (re-SPYR-a-to-ree) system. Look again at the diagram and name the organs of the respiratory system.

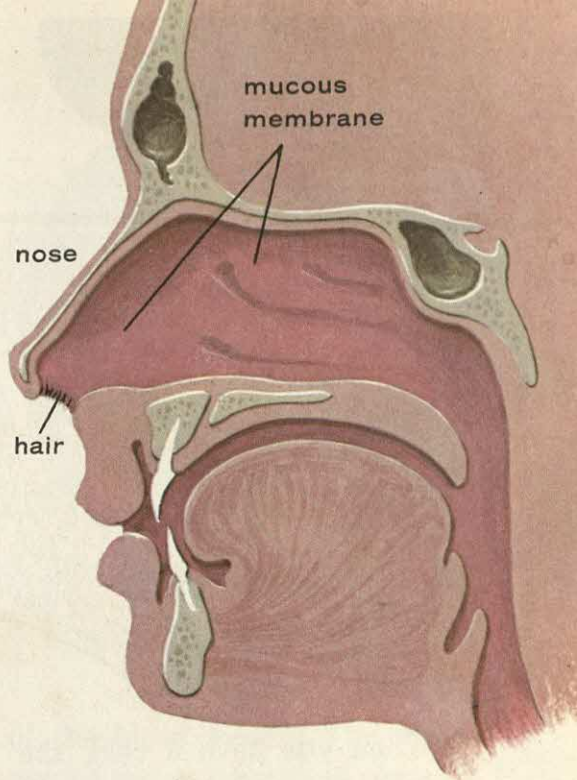
The Nose

The organs of your respiratory system are lined with a very thin, shiny mucous membrane. This membrane is kept moist at all times. This is the same type of tissue that you see and feel inside your mouth. Dry air that passes through your nose is moistened by the mucous membranes.

Microscopic hairs are part of the mucous lining of your nose. These hairs are moving and work together to filter out dust particles and clean the air as it passes from the nose to the windpipe or trachea (TRAY-kee-a).

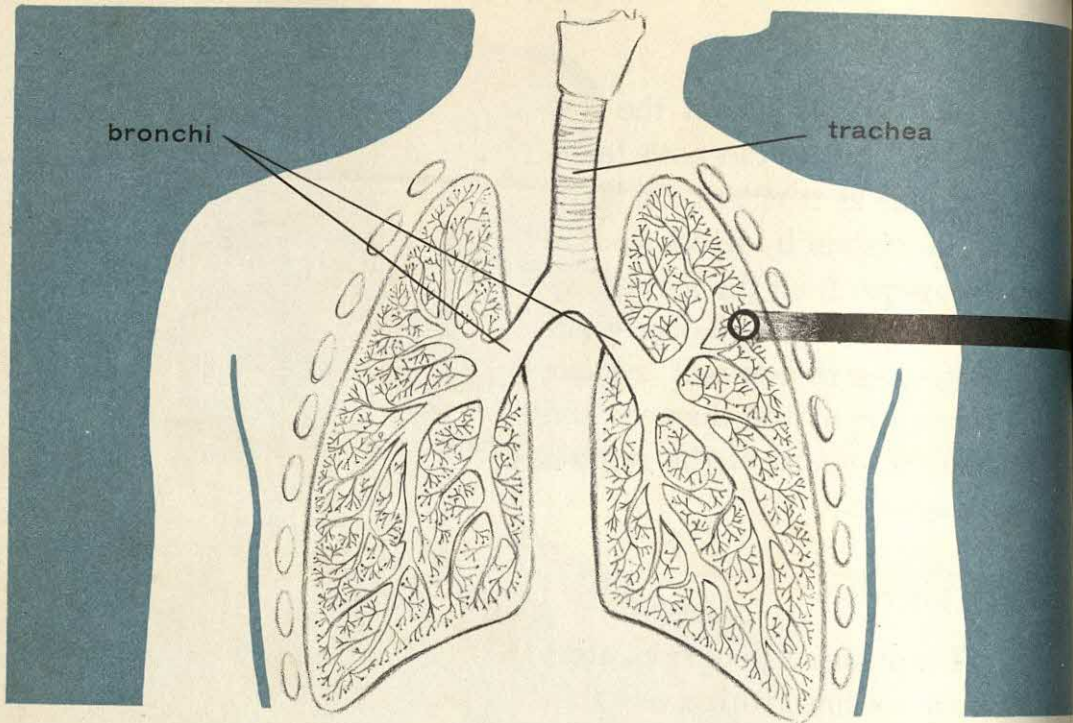
The tissue that lines your nose has many small blood vessels. One important purpose of these blood vessels is to warm the air as it passes through the organs.

The air you inhale, therefore,



is moistened, cleaned, and warmed as it passes through your nose. It is important to keep the passages of your nose open and clean. The next time you blow your nose, remember to blow gently and from both nostrils at once. You will be helping this important part of your body to do its work as thoroughly as possible, for as long as possible.

Now that you know a little about the structure of the nose and its work, why do you suppose it is not advisable to breathe through your mouth?



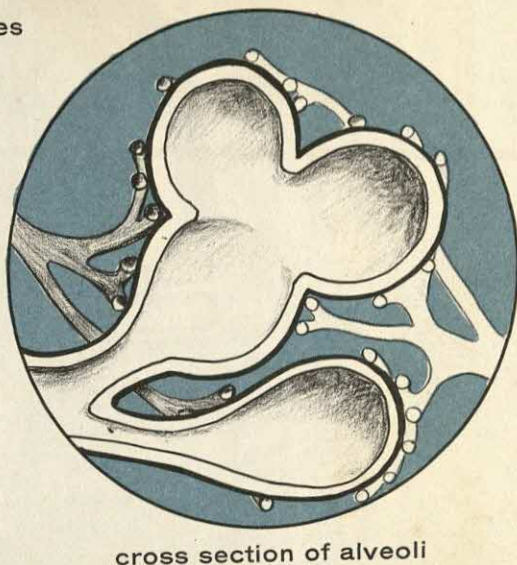
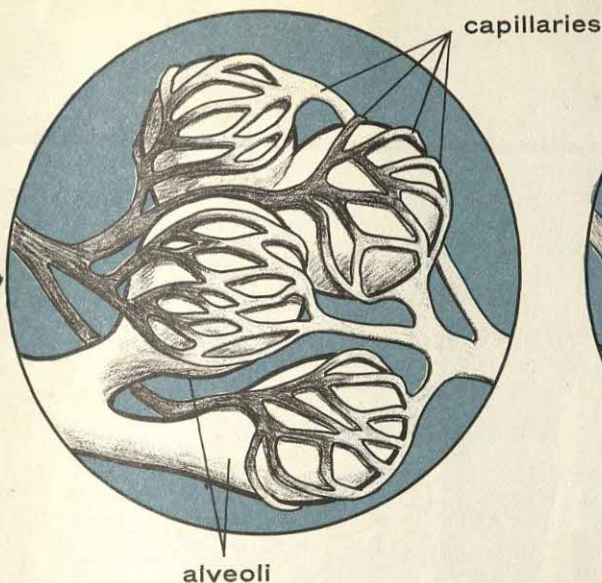
When you have a cold, the mucous membrane of your nose swells. The passages fill with fluid. Sometimes you cannot breathe through your nose. Think of your mouth as an emergency opening for breathing, to be used only when the nose is unable to do its job.

Tubes That Lead to the Lungs

The trachea or windpipe, as you can see in the picture, connects the upper part of the respiratory tube with the lower parts. It is lined with the same type of tissue as the nose. The trachea has very tiny, hair-like structures that move to sweep foreign particles up and out.

Has soap powder or pepper ever made you sneeze? Dust or any fine particles of this kind may irritate the mucous lining of the respiratory tube. You respond to the irritation by sneezing or coughing. What else might cause an irritation like this?

Find the trachea in the diagram at the top of this page. Notice how the lower part of the trachea branches into two tubes. These tubes are known as bronchi (BRONG-ky). One goes to the left lung, and the other to the right lung. The lungs, which are made of spongy tissue, hang from the bronchi like two balloons. The lungs occupy most of the space in the rib cage.



Air Sacs in the Lungs

Within each lung, the bronchi divide again and again, getting smaller with each division until they end in tiny balloon-like air sacs. These air sacs are so small that they can be seen only with the use of a microscope.

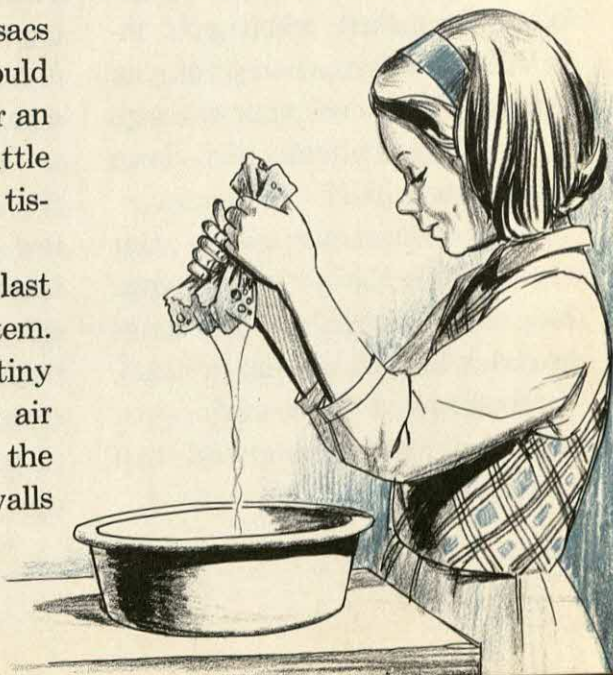
If you were to see the air sacs under a microscope, they would look like a bunch of grapes, or an inverted cauliflower. These little air sacs make up the spongy tissue of the lungs.

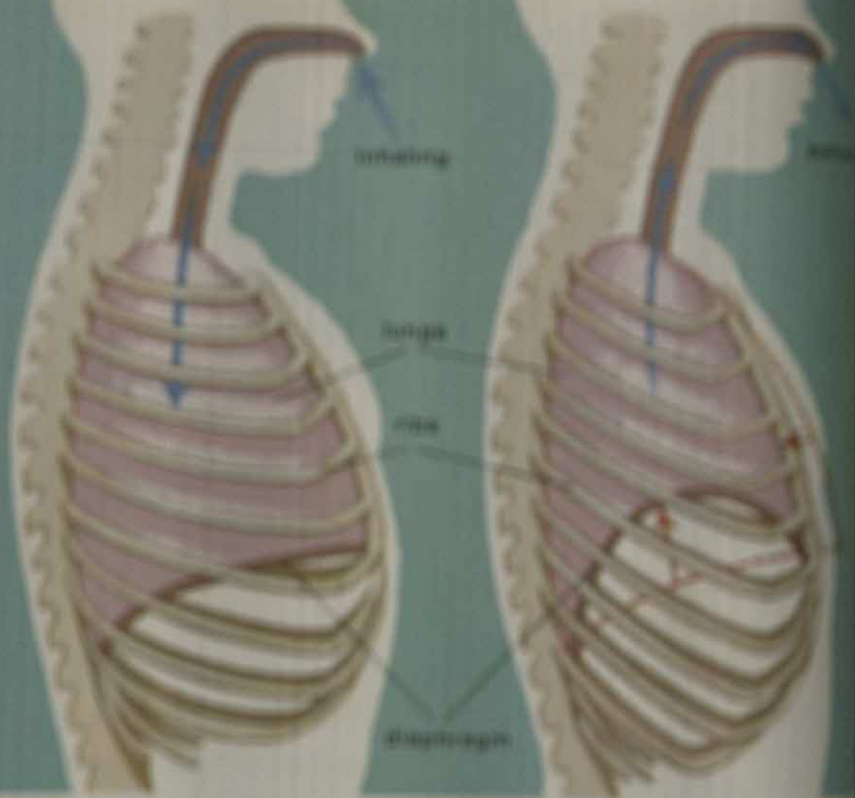
The air sacs are the last parts of your respiratory system. The air sacs are lined with tiny blood vessels. Air enters the air sacs. Then the oxygen in the air passes through the thin walls

of the blood vessels. The blood carries the oxygen to all parts of your body.

Breathe In, Breathe Out

Look at your chest and take a deep breath through your nostrils. Hold your breath for about





Steady sounds. Slowly let it out. What happens to your chest? What happened when you inhaled? What happened when you exhaled? Why does your chest go up when you inhale and down when you exhale?

All of the movement in your chest forces the air out of your lungs. After you exhale your lungs are back in their normal position. As soon as you inhale again, your lungs will again expand and then contract.

Look at the picture. The bony structure of the chest is the rib cage. The space inside the rib cage is called the chest cavity. What is a cavity?

Your rib cage extends from the base of your neck to just a few inches above your waist in front, and to your waist on the sides and in back. Your ribs are made of sturdy bone. One of the main purposes of your rib cage is to protect the organs of respiration that are within it.

Directly under the rib cage is a large muscle, called the diaphragm (see above), that controls breathing.

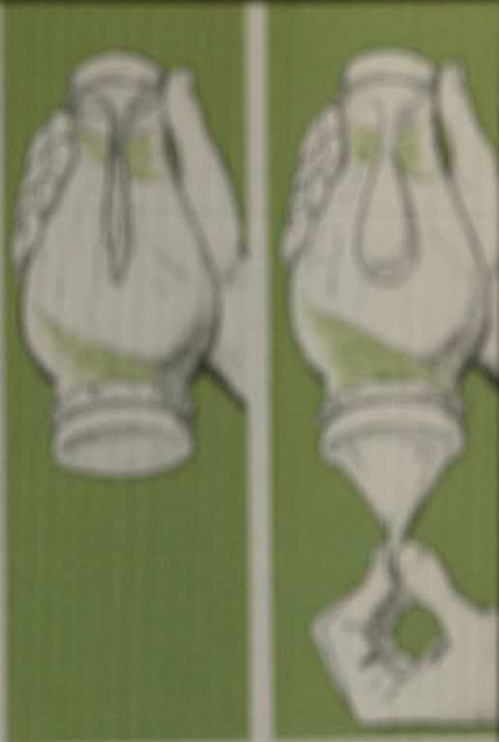
A muscle works by tightening and relaxing. When the diaphragm is relaxed, it looks like a dome that fits perfectly under the rib cage and fills up the space at the bottom of the chest cavity. As the diaphragm tightens, it flattens along the bottom of the rib cage. What change does this cause inside the chest cavity?

INVESTIGATE

Fit the chimney of a horizontal bag with a rubber balloon and a piece of rubber sheeting as shown. Pull down on the rubber sheeting. What happens? Why? (1-)

When you pulled down on the rubber sheeting, you decreased the air pressure inside the chimney. When the diaphragm flattens, air pressure in the chest cavity is decreased. Air rushes in through the nose and trachea to equalize the lungs. It pushes into all the tiny air sacs where the oxygen of the air is exchanged for carbon dioxide. The blood vessels bring carbon dioxide to the lungs.

When the lungs are full, the diaphragm begins to relax, and



the lungs contract. With the return of the diaphragm, the lungs begin to empty and you begin to exhale carbon dioxide.

What have you learned about breathing and respiration? Which gas from the air do you need to live and grow? How is the air removed, changed, and returned to it when you breathe? How does the diaphragm work? Do you breathe carbon dioxide? Does your blood carry oxygen? What is fresh air? How does a room full of people breathe? How proper position helps the breathing process?

The Circulatory System

The Next Step

Your body can take the oxygen from the air you breathe and gradually pass it into the tiny blood vessels in the lungs. The food you eat is broken down in digestion. Then it is absorbed into the tiny blood vessels in the small intestine. What happens to the oxygen and the digested food after they enter the blood stream?

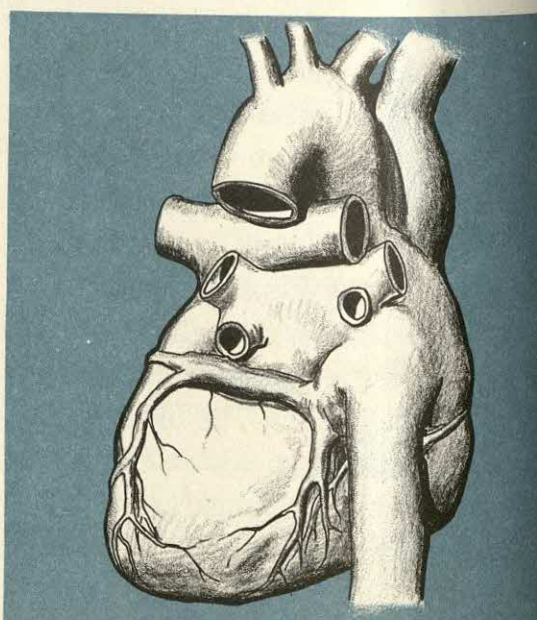
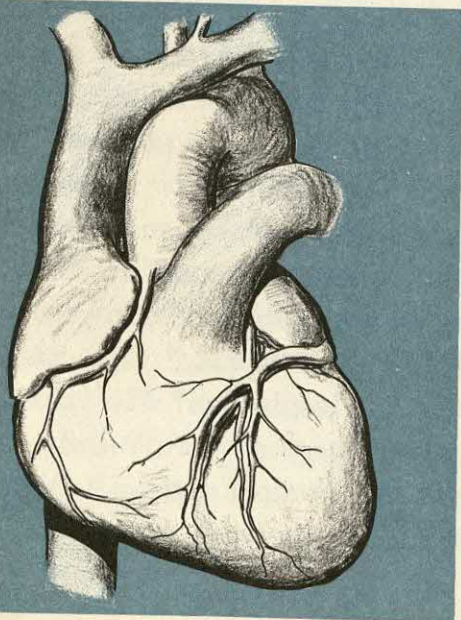
All parts of your body need the oxygen and digested food in order to live and grow. How do oxygen and digested food in the blood stream reach all parts of your body?

The Heart

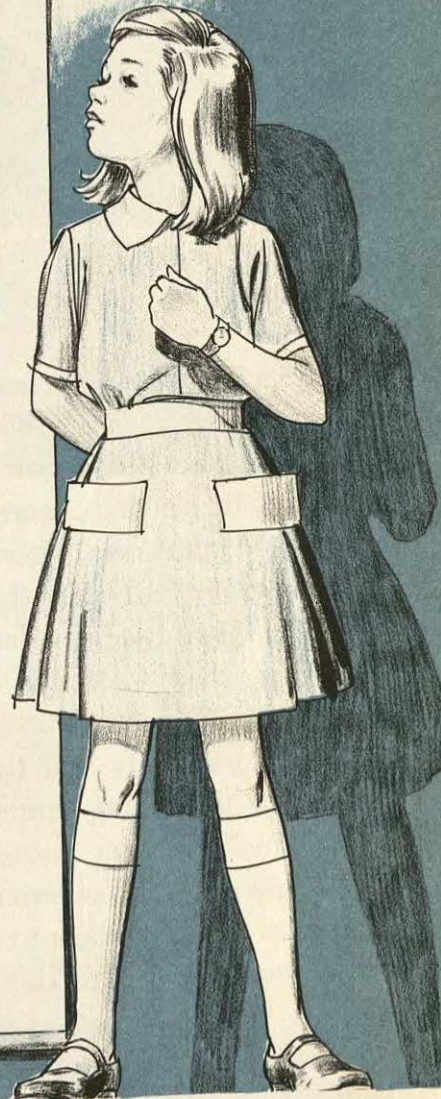
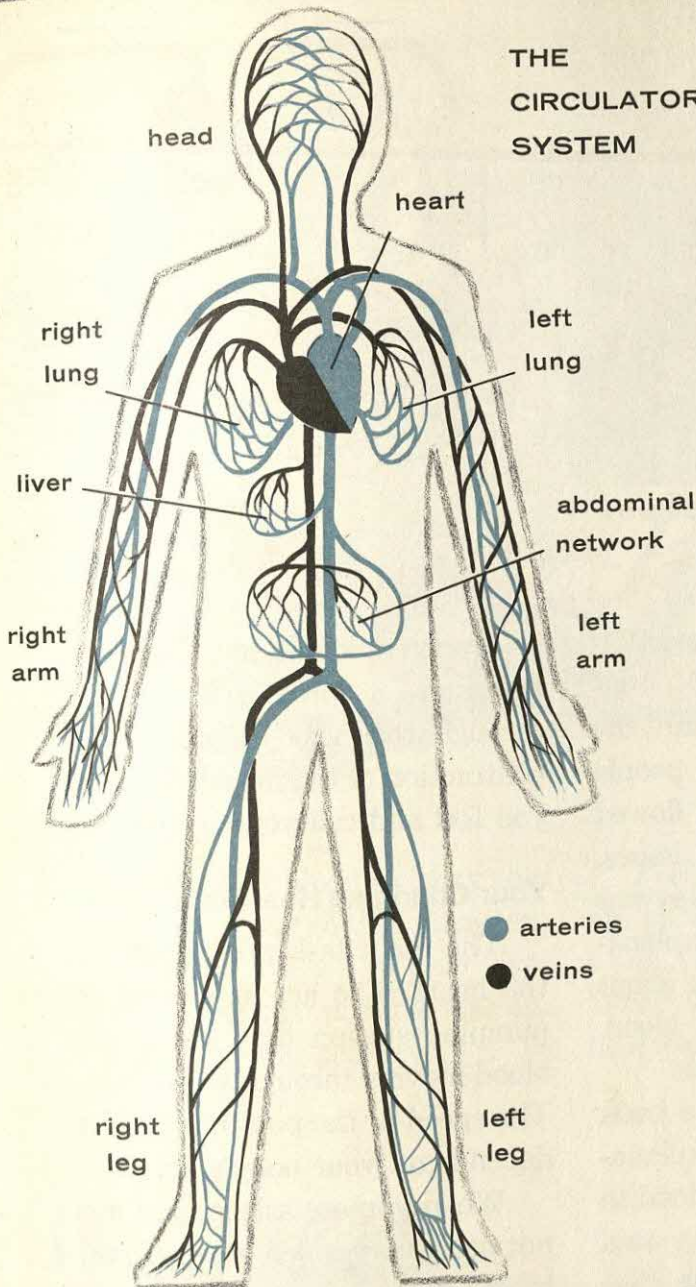
Just as the muscle called the diaphragm controls the working of the respiratory system, a hollow muscle called the heart keeps the blood traveling throughout your body in an orderly way.

LOCATE

Locate your heart. Make a loose fist with your left hand. Place it over the center of your chest, and pull your fist slightly to the left. Point your thumb toward your right shoulder to make sure your fist is in the right position. This is where your heart is.



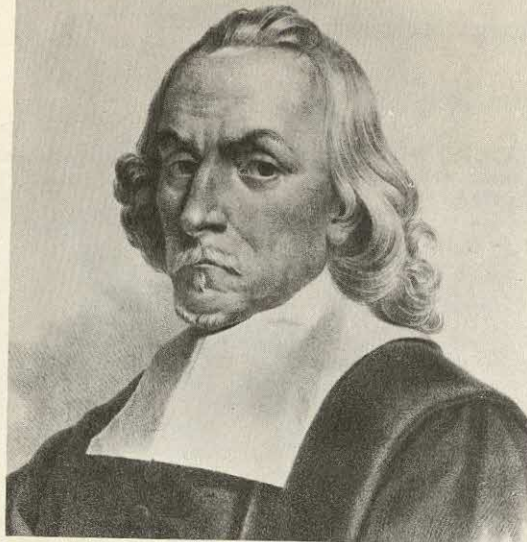
THE CIRCULATORY SYSTEM



Can you feel your heart beating? Is it beating at a steady rate?

What is happening at every beat you feel?

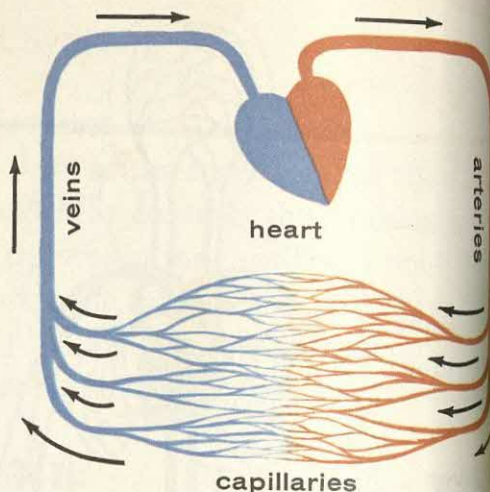




WILLIAM HARVEY 1578-1657

An English doctor named William Harvey (1578-1657) wondered about the heart and the blood. In his time, many people thought that the blood flowed slowly from the liver to the tissues, where it was used up. Harvey was not satisfied with this explanation. He read many books about the human body and the blood. He examined many animals.

Finally Harvey wrote a book in which he gave his own explanation of what happens to blood in our bodies. William Harvey said that the heart is a muscle that acts like a pump. The heart pumps blood through the blood vessels to the tissues. The blood then returns through other blood vessels to the heart.



Every time the heart muscle contracts, it forces blood along through the blood vessels. This contraction of the muscle is what you feel and call your heartbeat.

Your Changing Heartbeat

The main task performed by the heart is to act as a kind of pumping station that keeps the blood moving through your body. The speed of the pumping action depends on your body's activity.

When you are asleep, you are not using very much energy. You breathe slowly, and your heart beats slowly.

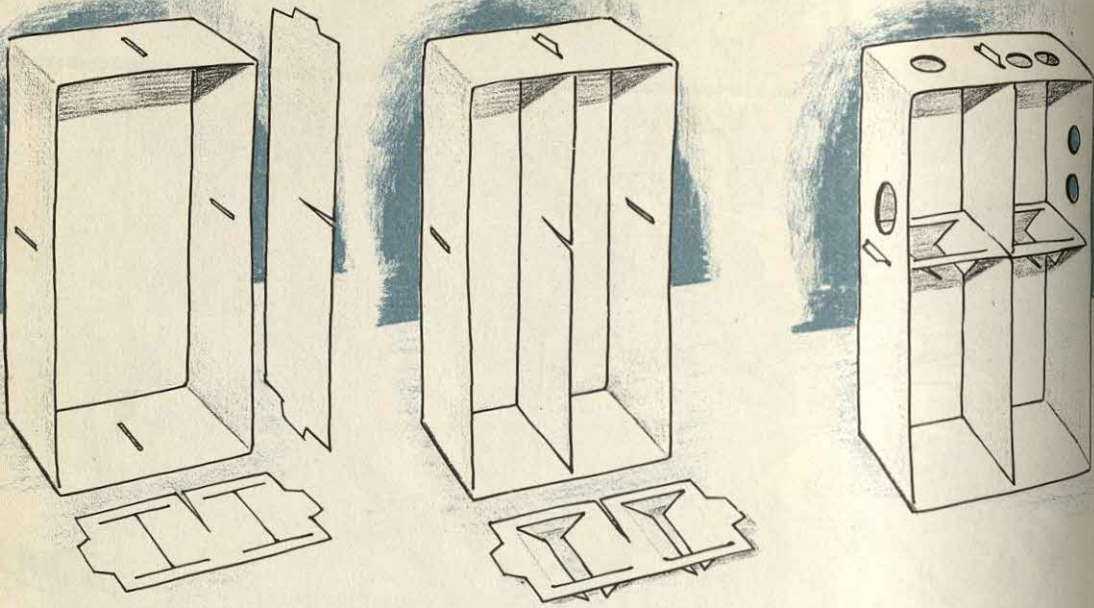
When you are running, playing, or working hard, you breathe fast to get plenty of oxygen into your lungs. Your heart beats fast



to enable your blood to carry the oxygen quickly to the muscles. The oxygen is used to help give energy to make it possible for you to continue your activity.

Feel your heartbeat while you are sitting quietly. Feel it again when you are playing outdoors. What do you notice about your heartbeat?





ACTIVITY

You can make a model heart from a shoebox. It will not look much like a heart, but it can help you to understand how the heart works.

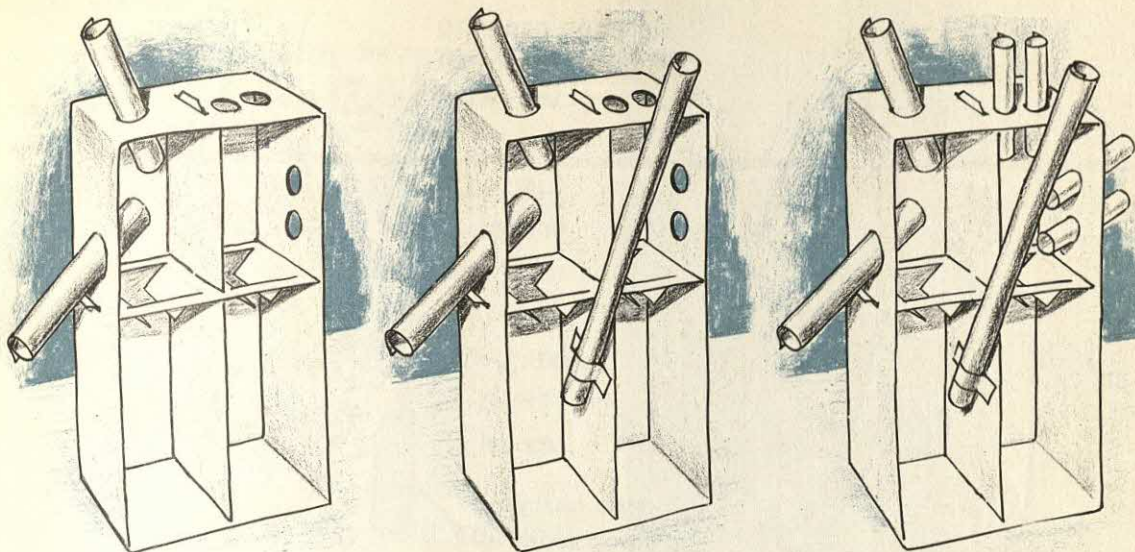
The heart is divided into two halves, the left half and the right half. Each half has two chambers. The upper chambers are the auricles (OH-ri-k'lz) and the lower chambers are the ventricles (VEN-tri-k'lz). The upper chambers are smaller than the lower chambers. The auricles are merely containers where blood collects while the ventricles work to keep it moving to all parts of the body. Make dividers to separate the left and

right halves of your model heart, and the auricles and ventricles.

Blood can enter each ventricle of the heart only through special one-way openings called valves. The valves let the blood move in the proper direction and prevent the blood from backing up. As a ventricle of the heart fills with blood, its walls push in, and the pressure closes the valve.

There is a valve between the right auricle and the right ventricle, and another between the left auricle and the left ventricle. There are no valves or other openings between the right and left halves of a normal heart.

In your model heart, make



valves between the right auricle and ventricle, and the left auricle and ventricle.

Blood from the trunk, limbs, and head returns to the heart through two great veins. These veins enter the right auricle. Add these veins to your model heart.

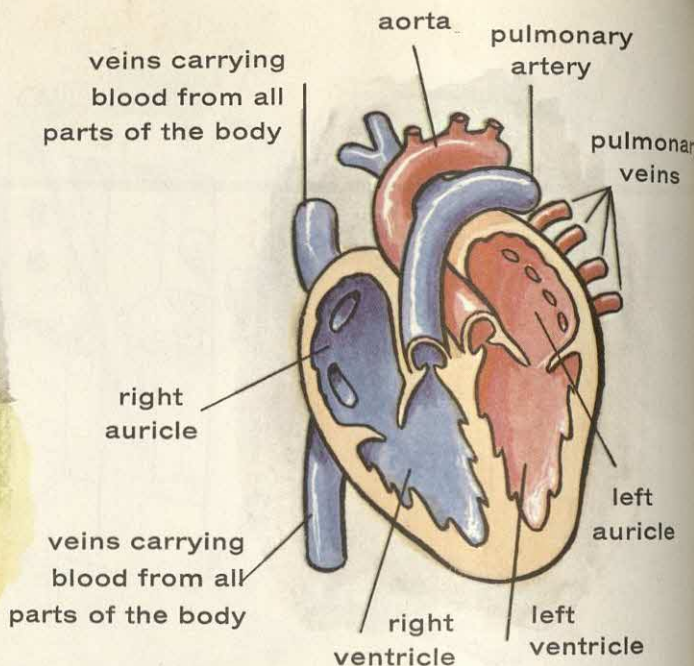
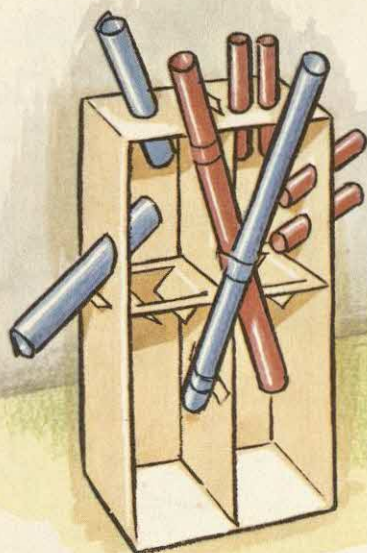
When the heart muscle relaxes, blood from the auricles flows into the ventricles. When the heart muscle tightens, the blood is forced out of the ventricles and pumped into the major blood vessels.

Blood from the right ventricle is pumped through a blood vessel that leads to the lungs. This blood vessel is called the pulmonary

(PUL-mo-ner-ee) artery. Add the pulmonary artery to your model heart.

The pulmonary artery branches into two smaller tubes, one of which enters each lung. These two branches divide and subdivide until they are the microscopic capillaries surrounding the air sacs of the lungs.

When the blood reaches the capillaries in the lungs, it absorbs the oxygen from the air you inhaled and gives up carbon dioxide to be exhaled. The pulmonary veins then carry the blood back to the left auricle. Add the pulmonary veins to your model of the heart.



The oxygen-bearing blood is pumped from the left auricle into the left ventricle. From here, it is pumped out of the heart through a large artery called the aorta (ay-OR-ta). Add the aorta to your model heart. The aorta branches into many smaller arteries, carrying blood throughout the body.

Now that your model heart is complete, use it to show how the heart works. Trace the flow of the blood through the heart, naming each part as you come to it.

The Blood Vessels

The heart pumps blood into the aorta and the dividing arteries under great pressure. This pres-

sure is needed to push the blood through parts of the body that are far from the heart.

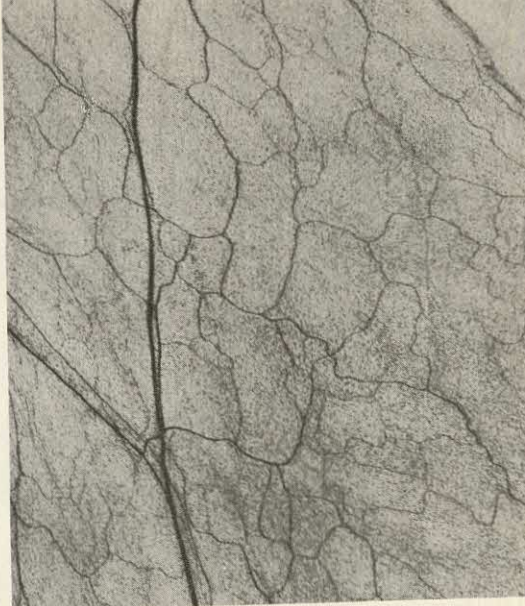
Because of the great pressure in the arteries, they must have thick elastic walls. For further protection, they are buried deep under the skin. You cannot see an artery, but you can feel the pulsing of the blood. To feel your pulse, place your fingers on the inside of your wrist, about an inch or two below the base of your thumb.

The arteries that carry blood to the intestines branch off into the tiny capillaries that surround the small intestine. Here, the blood picks up digested food and

transports it with the oxygen as it continues to travel through your body.

Other arteries lead to the capillaries that supply blood to the other tissues of your body. The food particles and oxygen are absorbed by the cells where they are used to repair and build tissue. The oxygen and food particles are also used in cell respiration to provide the energy your growing body needs. What are the products of oxidation?

The blood collects the carbon dioxide and other wastes from the tissues. How does the body rid



capillaries

itself of carbon dioxide? What happens to other wastes?

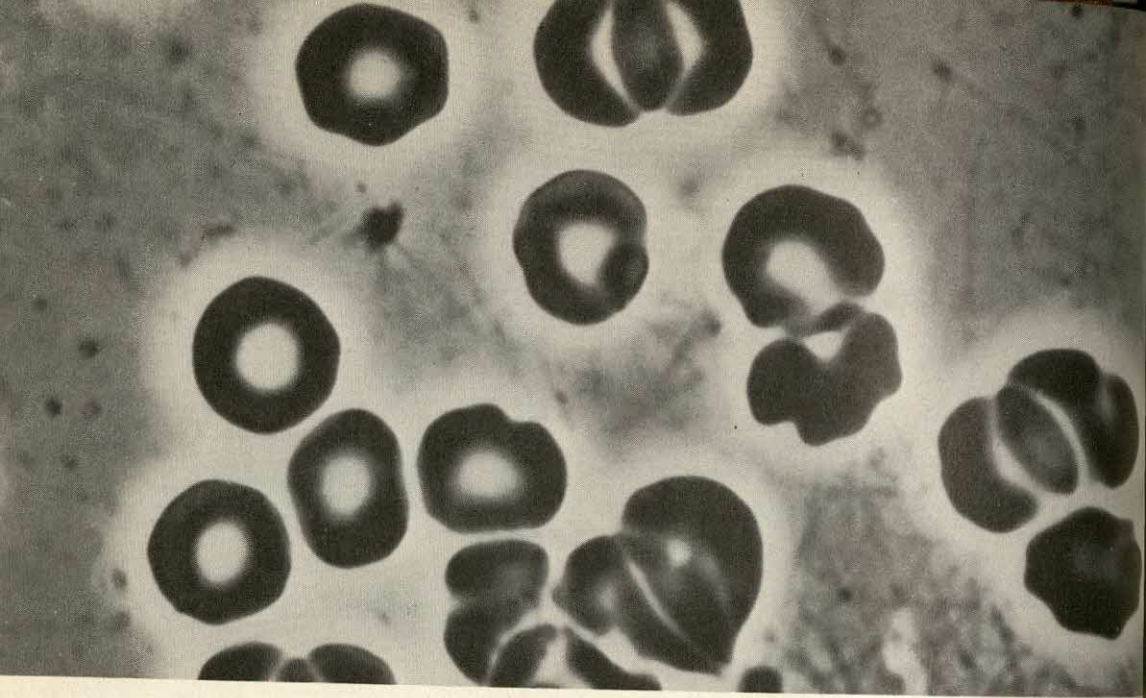
The capillaries gradually join again until the veins are formed. The veins get larger and larger until they meet at one of the two large veins that go directly into the right auricle of the heart.

OBSERVE

Look at your wrist. Can you see a vein? Your veins are closer to the surface of your body than the arteries. Why does the blood in your veins look blue? ☐ ☐

Remember that blood going back to the heart through the veins contains carbon dioxide. It is the carbon dioxide that gives the bluish color to the blood.





blood cells

The Blood

Your blood contains four main parts: a liquid, called plasma (PLAZ-ma), red cells, white cells, and platelets (PLAYT-letz). The plasma carries digested food particles and some waste materials, and the red cells carry oxygen and carbon dioxide. White cells fight infections in your body. Platelets help your blood to clot when you cut yourself.

Where does this important blood come from? Your body makes the materials that form your blood from the food you eat and drink, and the oxygen in the air you inhale. The red cells of the blood and most white cells are

made in the marrow of the bones. Other organs of your body also assist in making the white cells of the blood.

Trace the path taken by the blood from the time it enters the right auricle, through the heart and out to the capillaries, and then back through the veins to the right auricle.

By which blood vessels does the blood leave the heart? Where is oxygen in the blood exchanged for carbon dioxide? Where is carbon dioxide in the blood exchanged for oxygen? What happens to the other waste materials that the blood absorbs from the tissues of your body?

The Excretory System

Getting Rid of Wastes

Food taken into the body is changed by many processes into useful material for energy and growth. Your blood transports food to all parts of your body and collects the wastes that are not useful to the body. These wastes must be removed if your body is to remain healthy. The system that rids the body of wastes is called the excretory system.

Except for the solid waste matter resulting from digestion, most of the body's waste is water. Water is most important for life and for performing life processes. From 50 to 70 per cent of your weight is water. It is important for you to drink plenty of water and other liquids.

How do liquids assist in digestion? Why are they necessary for mucous membranes? Of what importance are they to the skin? What would happen if your body did not have enough water? What is dehydration? How does a prune look? What happens when it is placed in water? Why?

You have some knowledge of how the body rids itself of materials that are not useful for growth and repair. The excretory system separates or sifts out what is useful for the body from what is not useful.

The excretory system consists of the lungs, the rectum, the urinary system, and the skin. Which two of these do you know from your earlier studies?





The Lungs

The lungs are considered organs of excretion. Exhale into some limewater through a straw. What happens to the limewater? What gas was present in the air you exhaled?

Hold a mirror up to your mouth and nose for a few minutes. What appears on the mirror?

What are two products of oxidation?

The Rectum

From what you have studied about the digestive system, you know there are some materials in

food that have little or no value for growth and repair. These solid waste materials are pushed along the alimentary canal to the rectum, at the end of the large intestine.

Regularity Is Important for Good Health

A common name for the large intestine is the bowel. To empty the bowel or have a bowel movement every day is a healthy habit to form. It is to your advantage if this can be accomplished at the same time every day. If you must rush in the morning before school, aim at acquiring the habit in the evening, possibly after dinner.



Constipation is a condition that develops if one cannot have a bowel movement over a long period of time. The wastes stay in the rectum, and the little water that is present to keep the waste material soft continues to be re-absorbed. The solid material becomes so hard that it is difficult to expel it from the body. It may even cause pain. Sometimes it is necessary to take a laxative to get relief.

Constipation can be avoided. Here are some helps to avoid constipation.

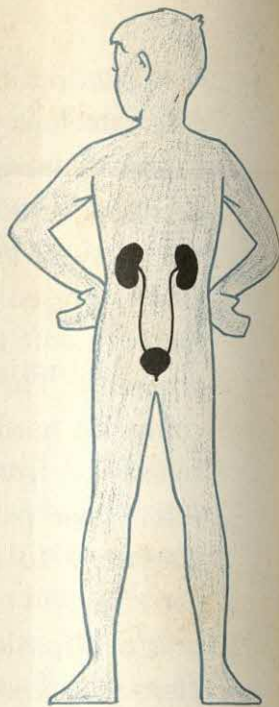
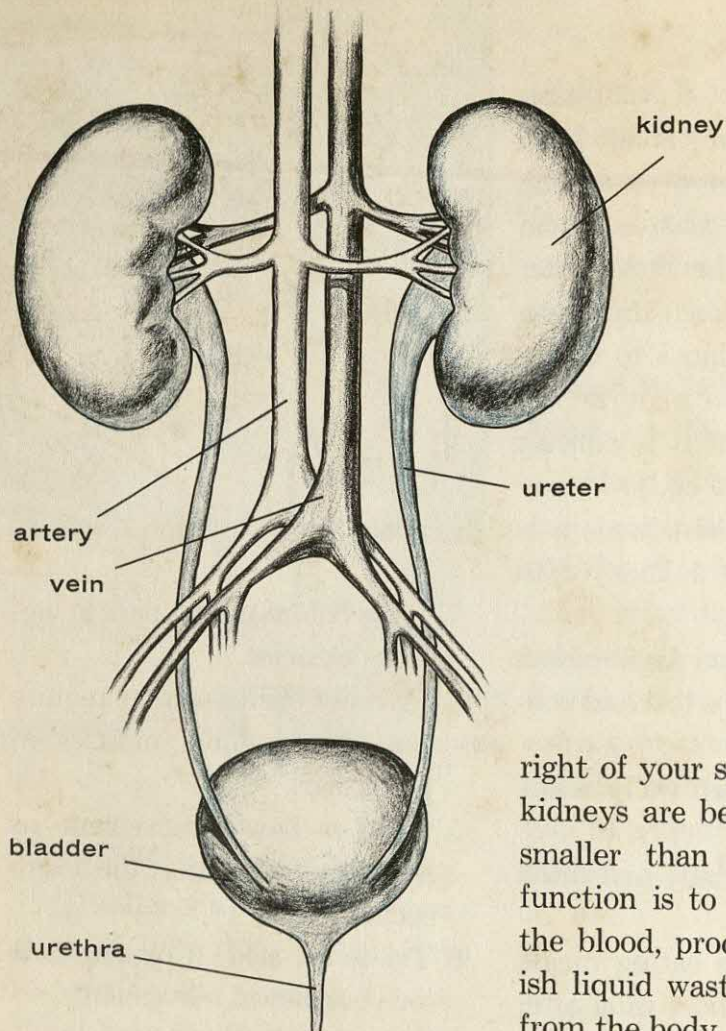
1. Chew your food well before swallowing it.
2. Eat some fruit daily and drink plenty of water.
3. Take your time eating meals, and rest for a short time after



meals before taking part in vigorous exercise.

4. Do daily exercises that require use of abdominal muscles in particular.
5. Have a bowel movement as soon as possible after the desire occurs.
6. Try to set aside a regular time for your bowel movement.





right of your spinal column. The kidneys are bean-shaped organs, smaller than the heart. Their function is to filter wastes from the blood, producing the yellowish liquid waste that is excreted from the body. This yellow liquid is called urine (yoo-rin).

The Urinary System

The urinary system of the body collects and gets rid of liquid wastes. It is made up of two kidneys, two ureters, the bladder, and the urethra.

The kidneys are located rather high up in the rear of the body cavity, a few inches above your waist in the back. There is one kidney to the left and one to the

Waste products are collected from the cells of the body by the blood stream. Arteries carry the blood to the kidneys. There, the blood flows through many capillaries. The capillaries come in contact with tiny tubes in the kidneys. The waste products pass from the blood through the walls of the capillaries into the tubes, and urine is formed.

Look again at the diagram of the urinary system. The long narrow tubes that extend from the kidneys to the bladder are called ureters (yoo-REE-terz). They are about twelve inches long. Through them, urine passes drop by drop to the urinary bladder below.

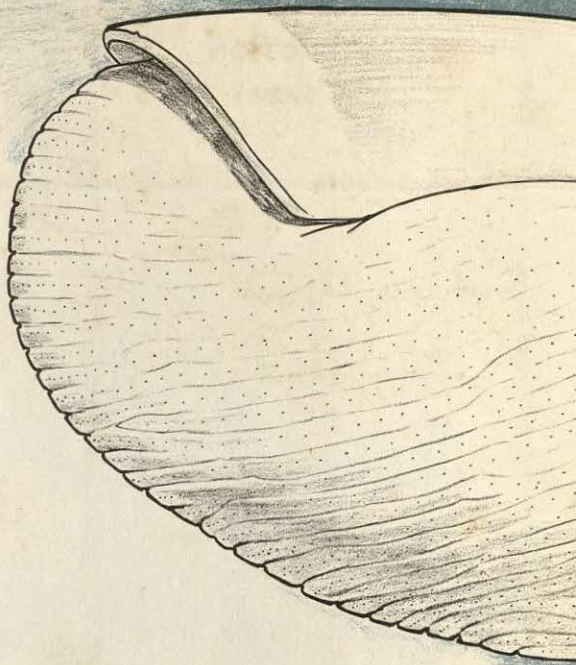
The bladder is a small, hollow, muscular bag. Its main purpose is to collect and store urine produced in the kidneys as it passes from the ureters. When the bladder fills, its muscular walls contract. The urine then passes to the urethra (yoo-REE-thra) and out of the body.

The Skin

Examine the skin of your hand with a magnifying glass. What do you see?

Your skin is more than a protective covering for your body. It is a sense organ, like your eyes and ears, that helps you to learn about the world around you. It serves as a temperature control system for your body. And, in a small way, it helps in the work of excretion.

Dip your hand in water and hold it in front of a fan. What do you notice? Your hand supplies the heat energy that is needed



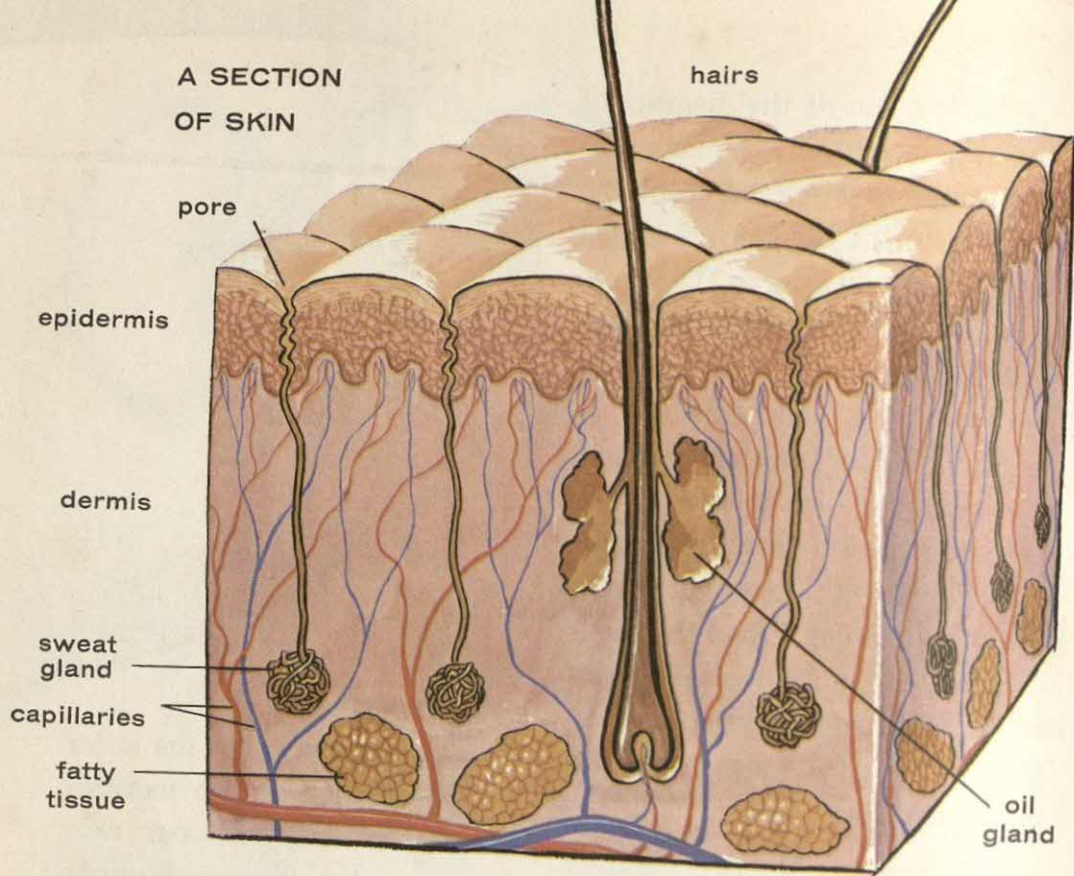
for the evaporation of the water.

Perspiration is the moisture you often find on your skin. It evaporates. This evaporation helps keep your body temperature even. Perspiration is mostly water, but also contains some waste material.

The perspiration is formed in tiny sweat glands in the deeper layers of your skin. It passes to the surface of your skin through holes or channels called pores. Did you see pores in your skin with the magnifying glass? How many pores can you count in a one-inch square of skin?

The skin consists of at least two different layers. The top layer that you can see and feel is the

A SECTION OF SKIN



epidermis, and the layer directly beneath it is the dermis. ("Dermis" means skin, and "epi" means on. Epidermis is really skin-on-skin.)

Look at the palm of your hand. Open and close it slowly. Why are there creases in your skin? If the skin on your hand were perfectly tight and smooth, could you bend your fingers? Does a baby's hand have as many creases as yours?

Keeping the Skin Clean

Care of the skin is a very important item for your good health.

If your skin is not properly cared for, the pores may become clogged. This prevents them from accomplishing their purpose. Why is it advisable to bathe often with soap and warm water?

Your hair, fingernails, and toenails are outgrowths of your skin and should be given as much care as the skin itself.

Hair should be brushed daily and neatly arranged. It should be washed as frequently as is necessary. Never allow it to become too oily. This oil is helpful to the hair. When there is too much oil

wash it away. Usually, washing your hair every week keeps your scalp in good condition.

Why should your fingernails be kept clean, and filed to the shape of your fingers? Why is it a good habit to keep your hands away from your face?

The skin between your toes must be kept clean and dry to prevent peeling or cracking. Athlete's foot, a skin disease, may develop if this condition is neglected for very long.

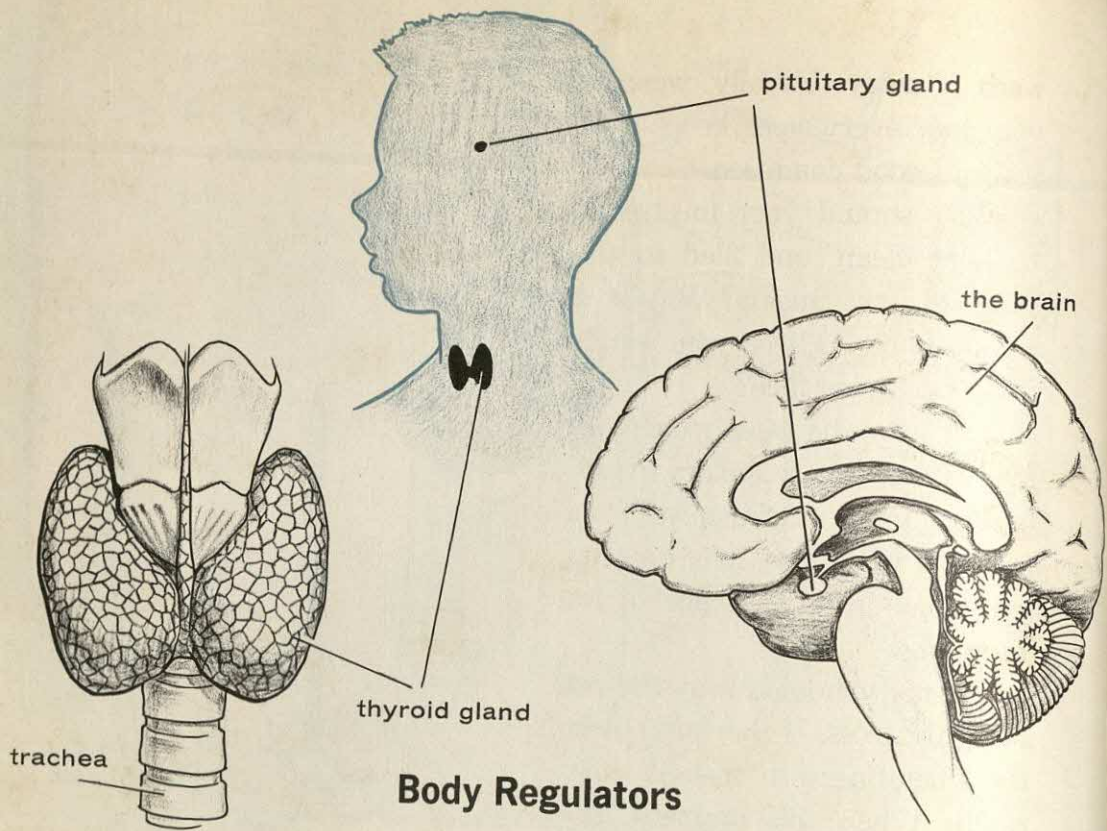
Toenails should always be cut straight across. If they are cut at the sides, ingrown toenails may result. When this happens, the



nail actually grows downwards into the flesh of the toe and may be very painful.

What have you learned about the excretory system? How do liquids assist in digestion? Name four ways in which the body gets rid of wastes. Why are the lungs considered organs of excretion? What are the organs of the urinary system? How should fingernails and toenails be cut? Why is the excretory system important to your growing body?





Body Regulators

Glands Control Growth

The human body has several special glands that regulate the way you grow. In the diagram you will see two of these special glands. What have you learned about glands already?

The Thyroid Gland

Look at the picture and locate the thyroid gland. This gland gives off a very important substance that regulates the speed of practically all the processes carried on by the cells of your body. Your body does not function prop-

erly if these processes go too slow or too fast.

Iodine is a very important part of the substance produced by the thyroid gland. What foods can you eat to keep your body supplied with enough iodine? If you do not eat seafood, you can get your iodine from iodized table salt.

The Pituitary Gland

The pituitary (pi-TYOO-i-ter-ee) gland is located at the base or bottom of the brain. It is often called the master gland, because

it has much to do with the way other glands function. One role of the pituitary gland is to regulate growth, particularly of the bones.

Other Body Regulators

Your body also has other glands that are most important to help boys grow up to become men, and girls grow up to become women. These special glands will have more work to do a few years from now. The substances they produce will bring changes that are part of your growing up.

How Are You Growing?

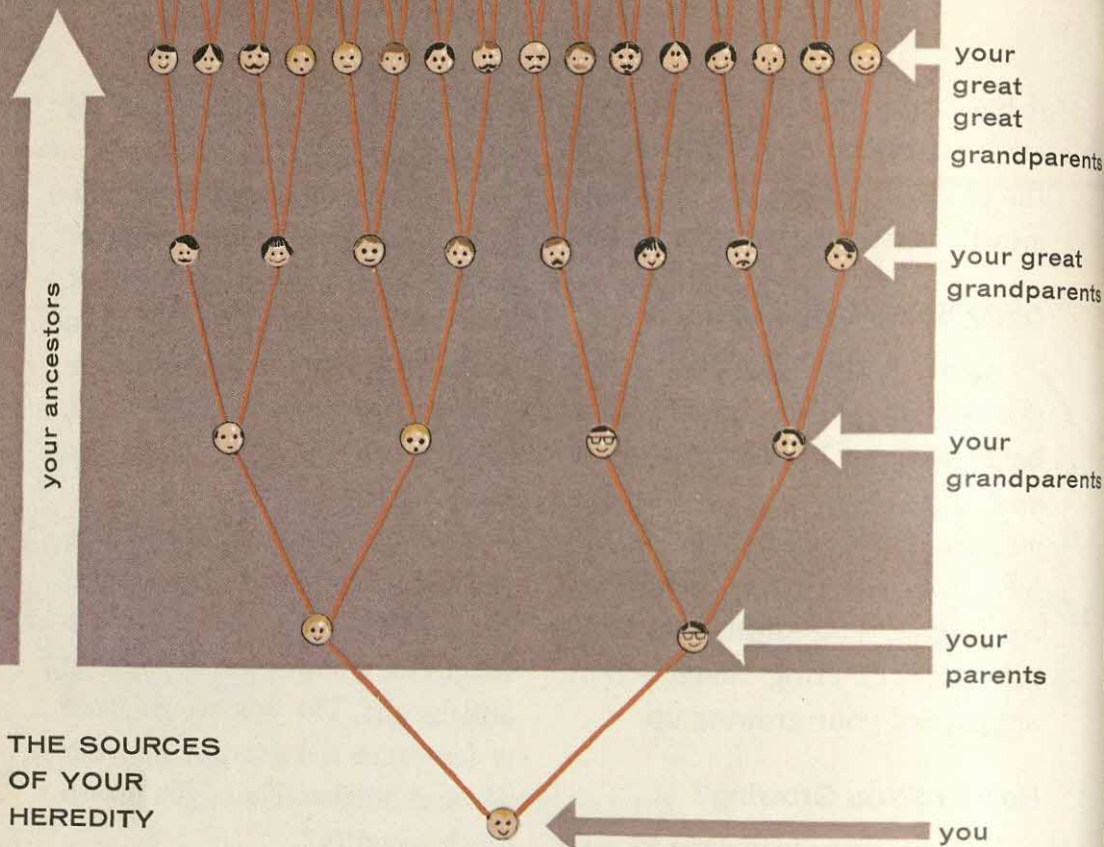
Do you mark from year to year

how much you have grown? If not, why not start now?

Not everyone grows at the same rate. You may be shorter than your friends this year, but some day you may be taller than they. Look around at your classmates. Are they all the same height? Do they all weigh the same amount?

How old are you? How tall are you? How much do you weigh? The chart gives the average weight for a boy or girl of your age and height. Do you weigh more or less than the average for your age and height? Have you grown much recently?

BOYS				AVERAGE WEIGHTS				GIRLS			
HEIGHT IN INCHES	AGE			HEIGHT IN INCHES	AGE						
	9 years	10 years	11 years		9 years	10 years	11 years				
	48	53	53		48	52	53				
	49	55	55		49	55	56				
	50	58	58		50	58	59				
	51	61	61		51	61	61				
	52	64	64		52	64	64				
	53	67	67		53	67	68				
	54	70	70		54	70	70				
	55	72	72		55	74	74				
	56	76	76		56	76	78				
	57	79	80		57	80	82				
	58	83	84		58		84				
59		87	59		87						
60		91	60		91						



Whom Do You Resemble?

What color is your hair? What color are your eyes? Are there others in your family with the same color hair and eyes?

You may have been told at some time or other that you look like your grandmother or grandfather or even like your aunt or uncle.

Your physical appearance has been passed on to you by your parents. The passing on of traits from parent to child is called heredity (he-RED-i-tee).

How Can You Improve?

Because you are you, and not someone else, you will be growing in your own special way. Because you are you, there is much you can do to help direct your growth. This is especially true about the growth of your body's bones and muscles.

Do you sit and stand tall? Do you eat the proper food? How do you care for your teeth? These are only some of the many ways you can help yourself to grow as a healthy human being.



Because you are you, and not somebody else, you are a very important person. You must know how to take care of yourself. What are you doing to keep healthy? Check yourself and see how much you have improved by what you have learned this year.

How do I rate physically?

What are my eating habits?

Have I tried to improve my eating habits?

What are the Four Basic Foods?

Do I get a balanced diet?

Do I drink plenty of liquids?

Do I take proper care of my teeth?

What is the proper way to brush teeth?

Do I visit a dentist every six months?

How do I care for my skin?

Do I take a daily bath or shower?

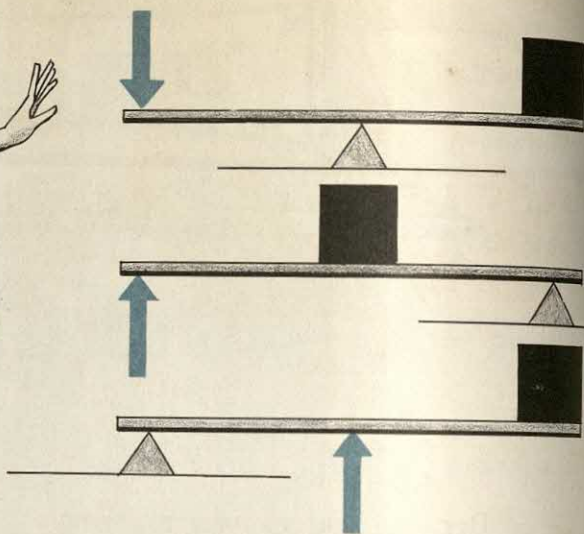
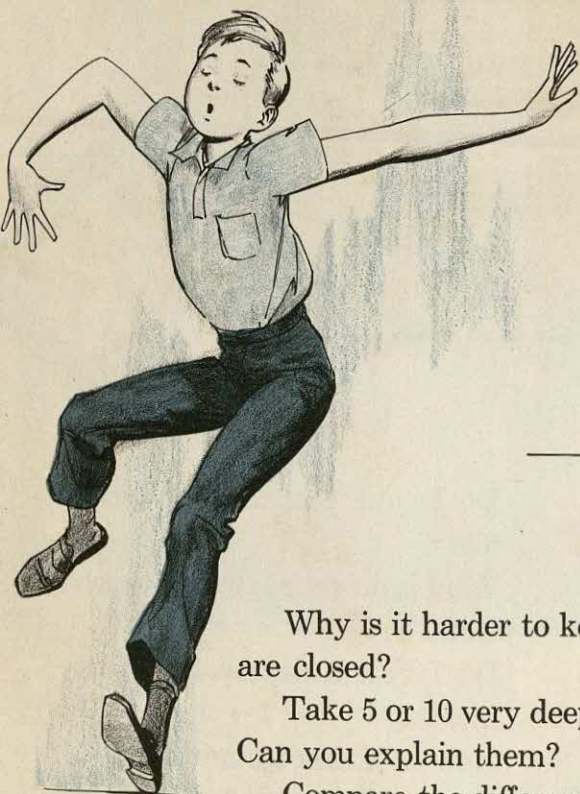
Are my fingernails and toenails filed and cut properly?

Do I sit and stand properly?

Do I get adequate rest in a well ventilated room?

Do I get enough exercise out of doors and in the sunshine?





THINK

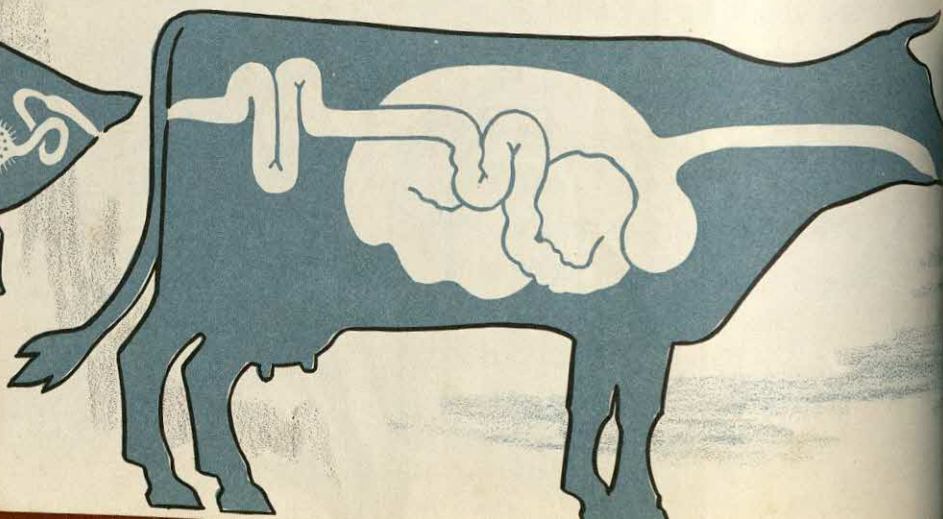
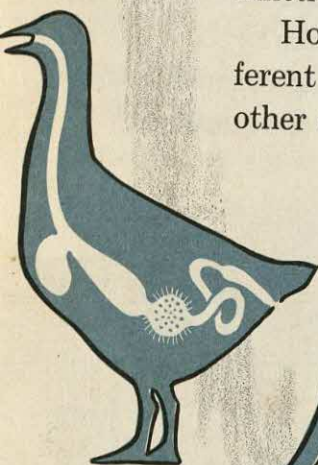
Why is it harder to keep your balance when your eyes are closed?

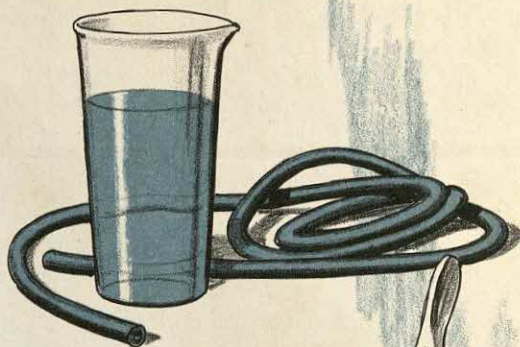
Take 5 or 10 very deep breaths. Describe your feelings. Can you explain them?

Compare the different types of levers with the muscle and bone systems in various parts of your body.

In a bird and in a cow, the stomach area is divided into 3 parts: the crop, gizzard, stomach. How do you think this arrangement helps the animals carry out their digestive functions?

How would you expect the heart of man to be different if he were living 10,000 feet above sea level? What other differences might there be?





PROJECTS

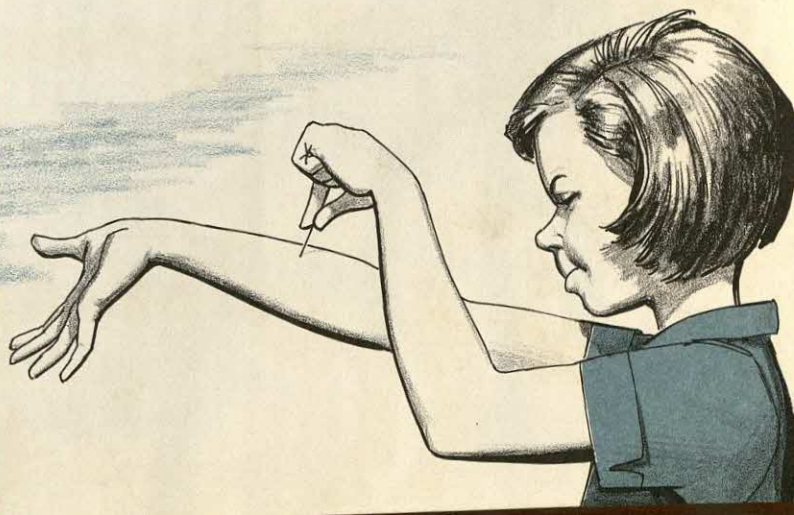
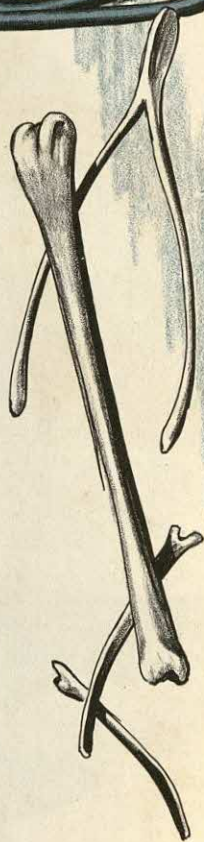
Locate and diagram the 4 taste areas of your tongue. Make a model for a kidney using only the principle of filtration.

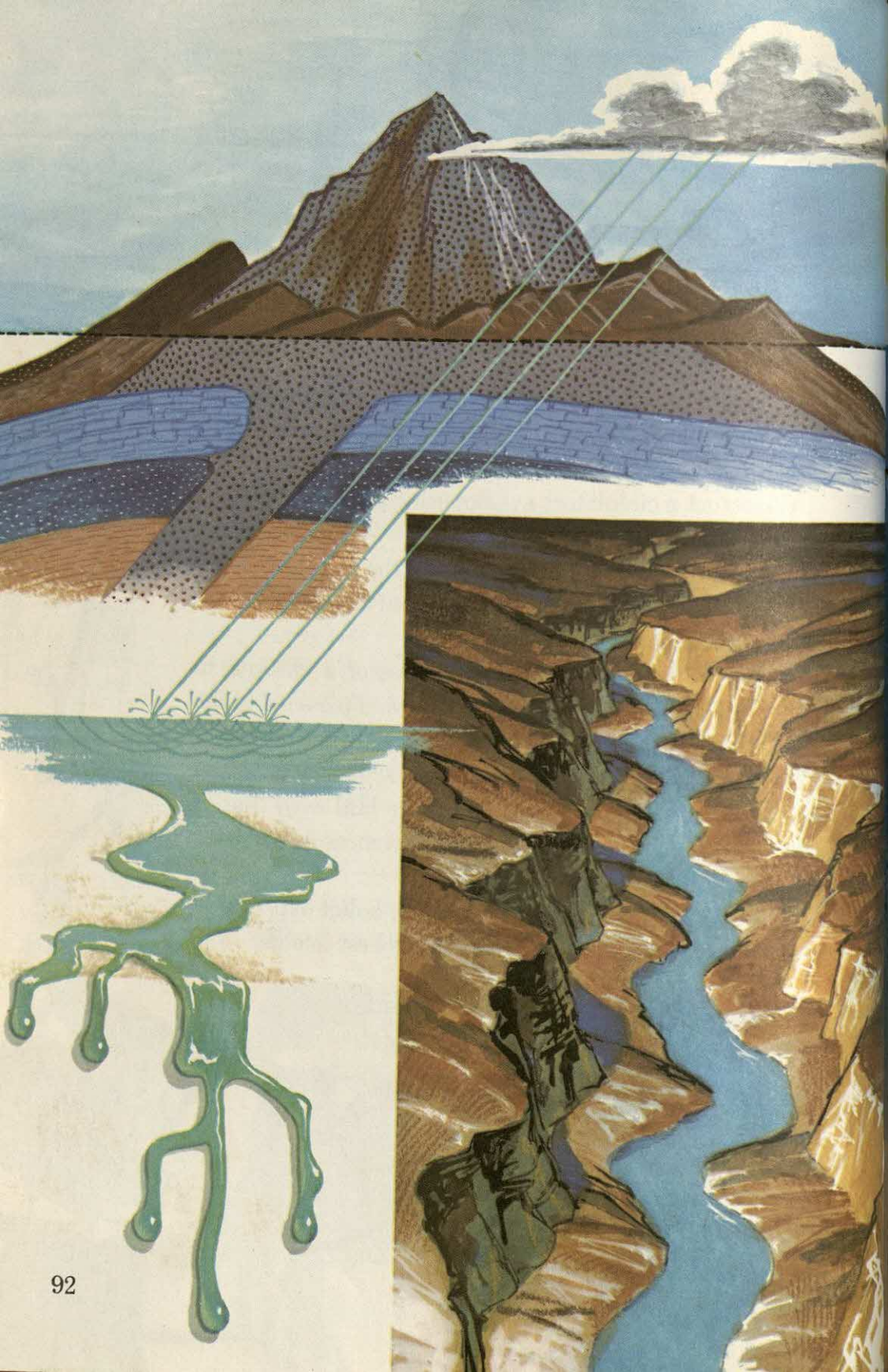
Construct a circulatory system using plastic tubing and colored water.

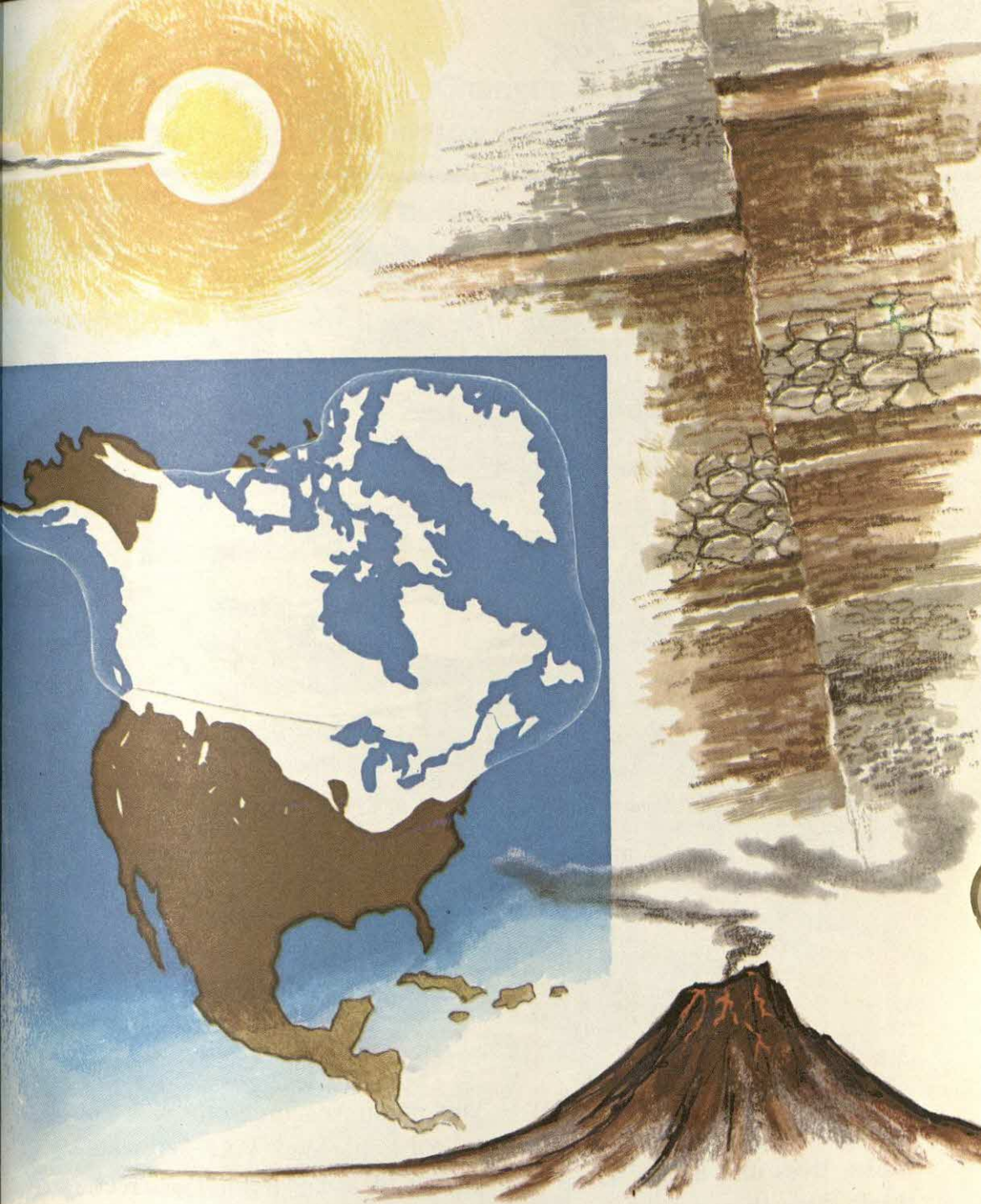
Use a pin to determine the areas of the body which are most sensitive to touch. Do you and your classmates agree on the conclusions?

Ask your mother to boil the bones of a chicken to remove all the meat. Let the bones dry and reassemble the chicken using pictures or other models to help you. Other types of birds can be assembled in a similar way. Compare the completed bone structure of a bird with that of man. Identify the similarities and differences in the bone structures.

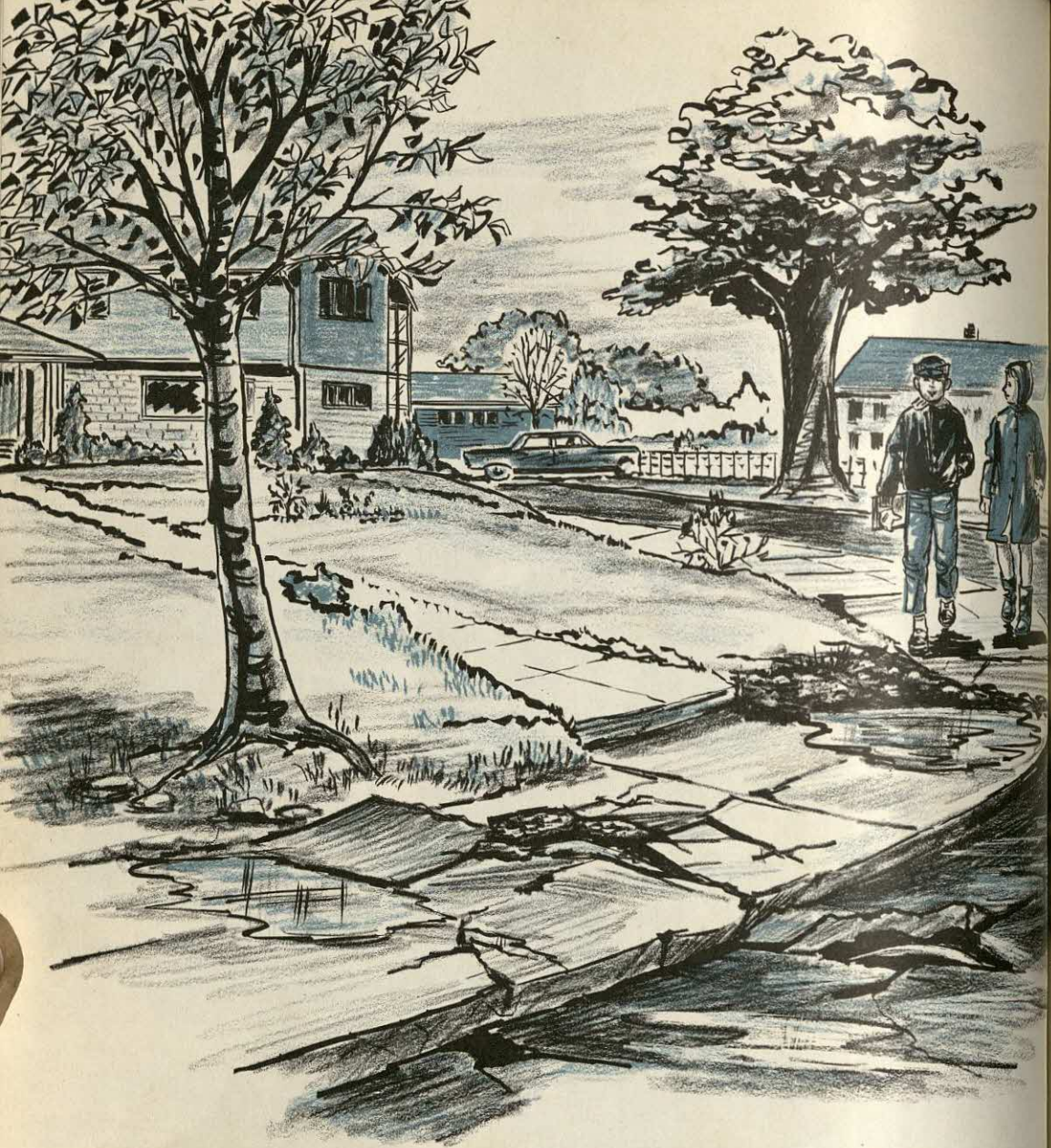
Raise white rats or guinea pigs. Try a diet experiment to see what types of diets promote the best health.







The Earth's Changing Surface



What did you see on your way to school today—streets and sidewalks, trees and lawns? Do you think these things will be different tomorrow? Do you think they will be different in some way?

What are some of the changes

you might see on your way to school tomorrow? You might see that dirt has blown into the street, or that soil from a lawn has washed across a driveway. You might find a place where tree roots are cracking the sidewalk.

Changes

Changes on the Earth's Surface

The picture below shows many different features of the earth's surface. Perhaps you have seen some of these features. A hill, for example, is a feature of the earth's surface that you have probably seen many times. Have you seen a river or a mountain? How many of the features in the picture can you name? Are there any of these features of the earth's surface near where you live?

You have observed changes in lawns and streets and sidewalks. The features of the earth's surface change also. However, you may not be able to notice these changes because they happen so slowly. A mountain may be worn down to a hill. A stream may grow into a great river. Flat lands may be carved into valleys, while other valleys are being filled by lakes. But such changes would take thousands, even millions, of years.





Fill a shallow box with loose, dry soil and place the box on a sheet of newspaper. Smooth the surface of the soil with a ruler. Now blow across the surface of the soil. What do you observe? Has the surface of the soil changed? How?

Place the box on another sheet of newspaper and sprinkle part of the soil with water. Once again, blow across the surface of the soil. What do you observe?

Is there soil on the first newspaper? How much? Is there soil on the second newspaper? How much? Does the wet soil move as easily as the dry soil? Why is there a difference?

EXPLORE

Have you ever tried to watch the hands of a clock move? Can you see the minute hand move? Can you see the hour hand move? How can you tell if the hour hand really does move?





INVESTIGATE

Cut a V-shaped notch in one end of an aluminum foil pan. Fill the pan with moist soil. Place the pan in another larger pan, and raise the uncut end by resting it on a block of wood. Each day for a week, pour a half cup of water on the soil at the top of the box.

Observe the results at the end of the week. What have you found out? How much soil has been washed into the larger pan? Weigh the soil. How many cups of water did you use? What would happen if you used more water? What would happen if you tilted the small pan more? What would happen if you continued the activity for a longer time?

Heat a small piece of soft rock, such as sandstone, over a flame for at least five minutes. Then drop the heated rock into a bowl of cold water. How did the rock change? What do you think caused the change?





EXAMINE

Boil a small piece of marble in vinegar for about five minutes. Remove the marble from the vinegar with a spoon. Set the piece of marble on a paper towel to cool. When the marble has cooled, examine it carefully.

Has the marble changed in any way? How has it changed? Do you think something new was formed? What do you think caused the change?

Fill a small jar with cold water. Be sure to fill the jar to the top. Put the cap tightly on the jar and wrap the jar in a dry cloth or a plastic bag. Use rubber bands to hold the wrapping in place. Put the jar in a freezer and allow it to stand overnight.

The next day, remove the jar from the freezer and unwrap it carefully. Has the jar of water changed in any way? Why? ☐ ☐

Each of the activities you performed has caused a definite change. Some of the changes happened quickly. Others happened slowly. Most of them were physical changes. One was a chemical change. All of them can help you to understand how changes in the earth's surface take place.





Wind

What Is Wind Like?

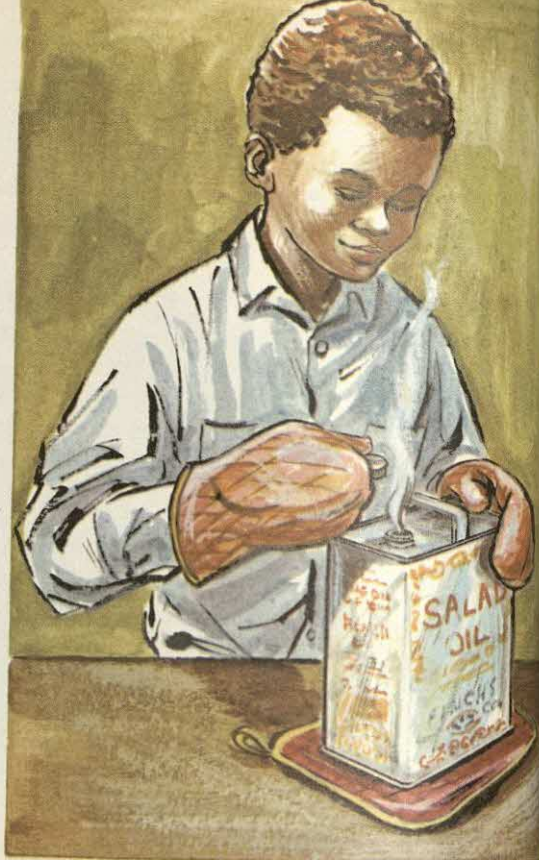
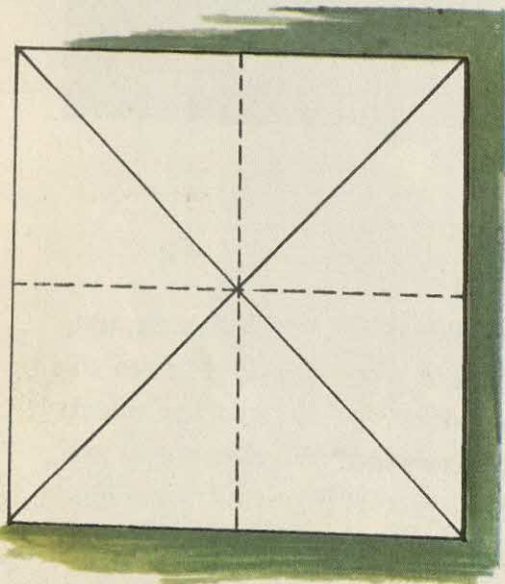
What is wind? Is there a place on the earth where there is never any wind? Have you ever seen the wind? Certainly you have heard the wind, but have you seen

it? When you see clothes flapping on a clothesline, do you see the wind or do you see the effects of the wind? What causes wind? How powerful is wind? Can wind push? How fast can wind move?

PREDICT

Take a gallon can of the kind shown in the picture. Wash the can out thoroughly, leaving a half inch of water in the bottom. Heat the can on a stove or hot plate until the water boils and steam comes from the opening. Using an oven mitt to protect your hand, put the cap loosely over the opening. Remove the can from the heat and quickly tighten the cap. Watch the can as it cools. What is acting on the surface of the can?

Mark a square piece of paper as shown in the diagram. Fold up on the solid lines and down on the dotted lines. Attach a thread to the center of the paper. Hang the paper over a radiator or a light bulb. What happens? Why? ☐ ☐



Air has weight. Air can push. Air moves. Air moving over the earth's surface is called wind. How does the sun's energy affect wind? Why do we say that the sun is the wind maker?

Wind is always blowing somewhere on the surface of the earth. Wind can be a gentle breeze that you hardly notice or a fierce hurricane of more than 100 miles an hour. One of the greatest wind speeds on the earth's surface was measured on top of Mount Washington in New Hampshire. A wind of 231 miles an hour was recorded there in 1934.

Wind Changes the Earth's Surface

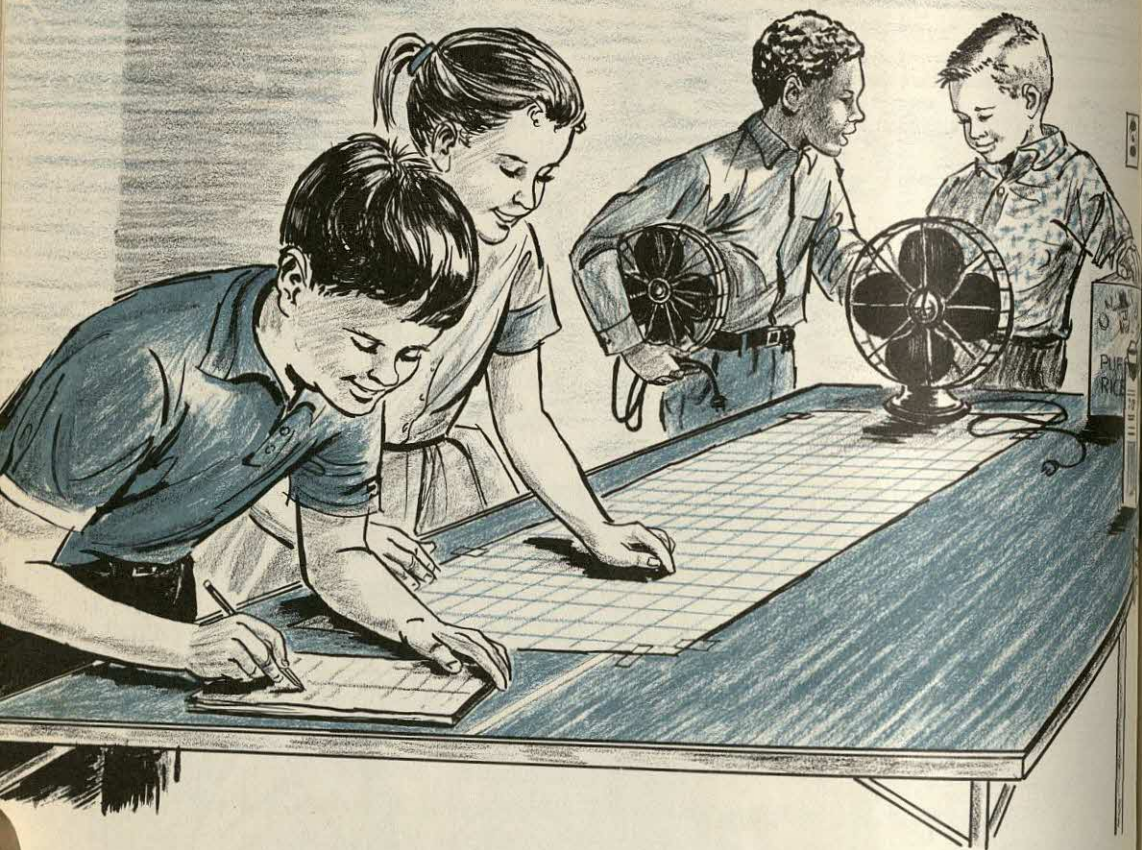
How can the force of the wind cause changes in the surface of the earth?

COMPARE

Using paper that measures at least 20 inches by 30 inches, mark off the paper into one-inch squares. Tape the paper to a table

in front of a fan. Place a table-spoonful of rice on the edge of the paper, directly in front of the fan. Turn the fan on. When the fan reaches a steady speed, count to 15 and then turn the fan off. How far did the rice move across the paper? What was the greatest distance that the rice moved? Did all the grains move the same distance? Record your observations.





Repeat the activity, using a tablespoonful of puffed rice. What do you observe this time? Record your observations.

Repeat the activity, using a larger fan. Does the large fan blow harder than the small fan? Can it move things farther? Record your observations.

Repeat the activity, using a mixture of minute rice and puffed rice. Compare the distances the two kinds of rice moved.

Test a tablespoonful of each of the following materials: sand, sugar, salt, talcum powder, and dry soil. Record your results.

Which material moved the greatest distance? How does each material differ from the others? Would you have recorded the same results if all the materials you tested had been wet? If wind were carrying a heavy material and a light material, which would be carried farther?

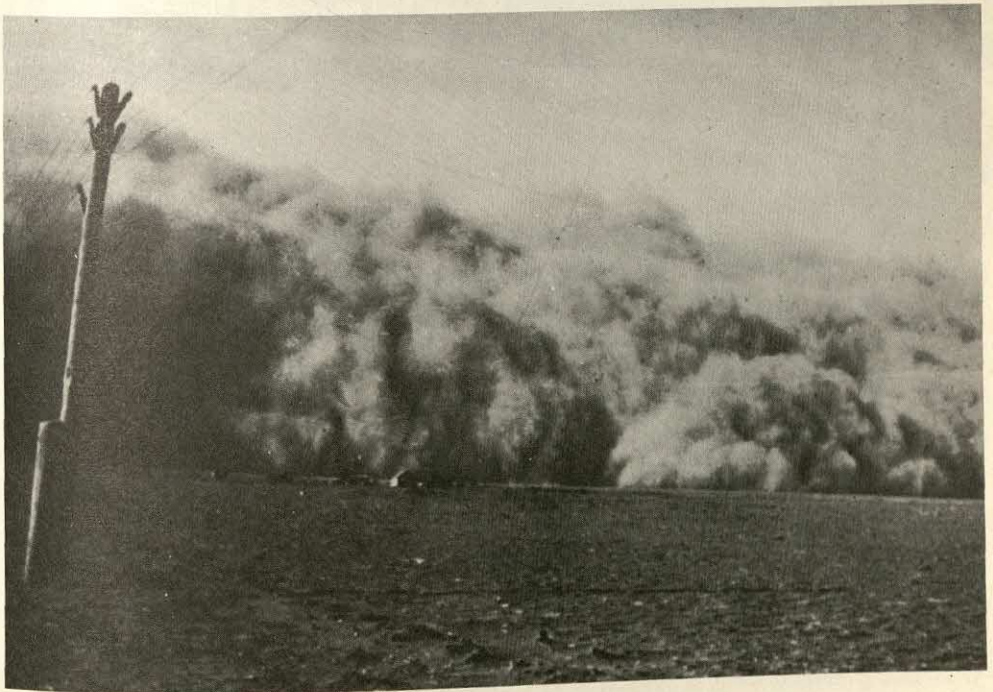
Wind, the Changer

What happened when you blew across the dry soil? What happened when you blew across the moist soil?

Can dry soil be blown away more easily than wet soil? In the 1930's, the middle western United States had several years of very dry weather, called a drought (DROWT). The drought killed farm crops and dried out the soil. Strong dry winds blew the soil away. In 1934, a single wind storm blew 300 million tons of soil eastward to the Atlantic Ocean. Thousands of farms were ruined because their topsoil was lost.

Might the soil have been lost if the weather had not been so dry? Suppose grass and other plants had been growing in the soil. Do you think the wind would have moved the soil so easily? Design some activities that will help you to answer these questions.

Wind erosion can cause the level of the land to become lower. Over a very long period of time, the land level in southern Wyoming has been lowered 150 feet because wind has carried away dust and loose soil. How many times your own height is 150 feet? How many floors would you expect to find in a 150-foot building?





MEASURE

If you live near a beach or sandlot, you can measure changes in the depth of the sand. Take a yardstick, or make one by marking one-inch lines in a strip of wood. Push one end of the stick firmly into the sand. What line does the sand come up to?

Observe the level of the sand on the stick for a long period of time. How can you make a record?

What results do you expect your record will show after one week? What results would you expect at the end of a month? Suppose you kept your record for a whole year, what changes might you discover? What might cause the changes? Will the place where you put the stick make any difference in your findings? Why? Do you think the sand level will get higher or lower? Why? ☐ ☐

Many of the deserts of the earth have been formed mostly by wind erosion. The first step in the formation of a desert is the loss of grass and other vegetation. When the topsoil dries up and its particles separate, the wind can carry the topsoil away. Once the topsoil is gone, the action of the wind continues to move the remaining soil, dust, and sand until sometimes only bare rock is left. Through man's carelessness, this can happen in just a few years.

Wind, the Builder

What happens to the soil or sand that is carried away by the wind? Examine the records you kept when you did the activity with the two electric fans. Did the small fan move the materials as far as the large fan did?

When wind loses speed, it deposits some of the materials it carries. The topsoil that the wind picks up in one place may be deposited in another, thousands of miles away.

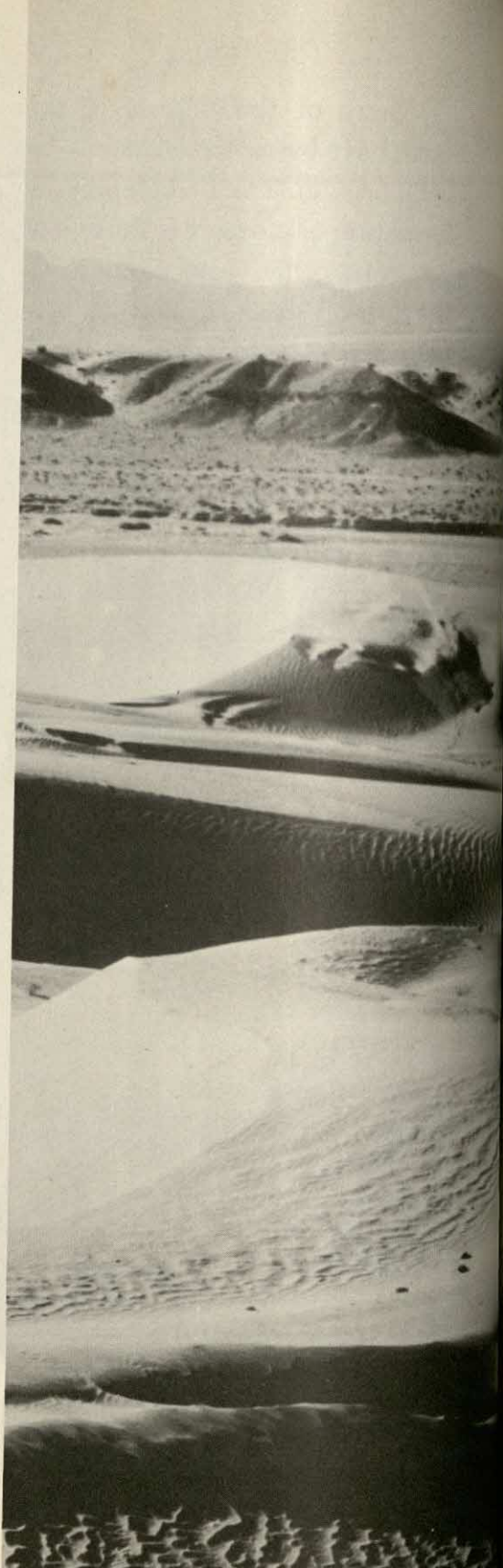


Windblown topsoils are called loess (LOH-ess). Deposits of loess often form rich farmlands, such as those of the Mississippi Valley.

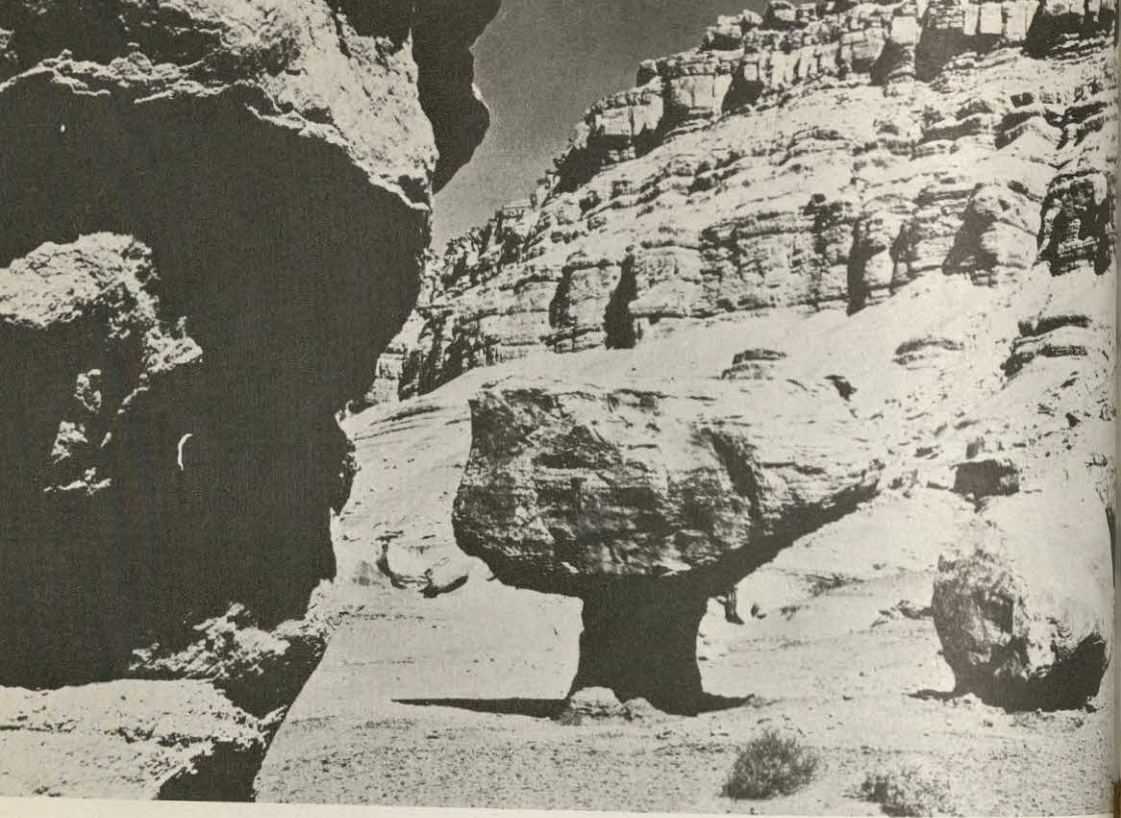
DISCOVER

What else can cause the wind to deposit soil and other materials that it carries? Set up the electric fan, the marked paper, and the minute rice again. What was the greatest distance that the minute rice moved? At half this distance, place an eraser. Turn on the fan, count to 15, and turn off the fan. What do you observe? □ □

When something gets in the way of the wind, it lessens the wind's speed. Sand dunes are built this way. Sand grass or rock can break the wind's speed. Then the wind will deposit some of the sand it is carrying. A large dune builds up with a gentle slope on the side toward the wind. If possible, examine a sand dune. Which side was toward the wind? Which side was away from the wind? Look at the photograph of the dunes. In what direction was the wind blowing when it formed these dunes?







Wind, the Sculptor

In many areas of the earth, wind-blown sand travels close to the earth. As the sand is blown against a rock, it wears the rock away. The rocks shown in the picture were shaped by wind-blown sand. How long do you think it might have taken to shape these rocks? What might the length of time depend on?

INVESTIGATE

Hold a piece of hard wood over a sheet of paper and rub the wood with coarse sandpaper for one minute. Do the same with a piece

of soft wood. Compare the amount of dust you get from the hard wood with the amount you get from the soft wood.

Take a small hard rock such as marble and rub it 100 times with a piece of medium-weight sandpaper. Note your results. Now take a piece of sandstone and rub it 100 times with another piece of sandpaper. What were your results this time? What was the difference between the two kinds of rock? Suppose you had sanded each rock 1,000 times. How long do you think it would take to wear the rocks away to dust? ☐ ☐

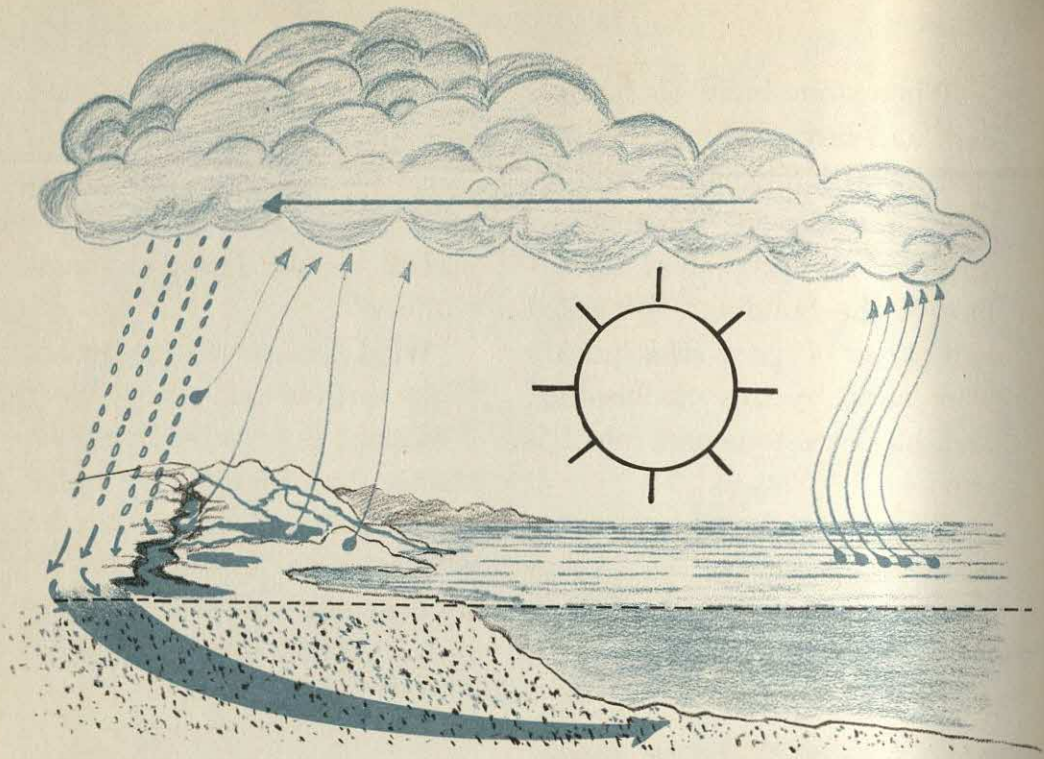
When stone buildings become dark and dirty-looking, they are cleaned with air-blown sand. A spray gun directs a high-speed stream of air and sand at the surface of the building. The soiled outer layer of the stone is quickly worn away by this sandblasting, and the clean stone underneath is exposed.

The men who operate sandblasting machinery wear heavy protective clothing. Why is this safety measure necessary?

Commercial sandblasting is a very quick process, compared to “sandblasting” in nature. Does wind always blow at the same speed? Are all rocks of the same hardness?

Wind can change the surface of the earth in many ways. What is erosion? How can wind erosion change the surface of the earth? What can be done to prevent wind erosion? How can the wind build up the surface of the earth? How does wind help to carve rocks?





Water

Water on the Earth

Wind is responsible for many changes in the earth's surface. But wind alone is not responsible for all the changes. Water, which covers more than 70 per cent of the earth's surface, is also at work making changes. In what ways do you think water could change the surface of the earth?

The earth's water makes up the oceans of the world. Water flows on and below the earth's surface to form lakes, ponds, rivers,

and streams. All the earth's water is part of a water cycle. The heat of the sun evaporates water into the air that surrounds the earth. Clouds form. Then the water returns to the earth's surface as rain, sleet, snow, or hail.

Remember the last time it rained? How long did the rain last—an hour, two hours, all day? Where is that rain water now? Next time it rains, watch the rain falling on the ground. Where do you think it goes?

EXPLORE

Weigh an empty drinking glass. Fill the glass with water and weigh it again. Water has weight.

Gravity pulls on water as it does on everything else on the earth's surface. Why does rain fall down to the earth? Why does rain water soak down into the earth? Does all the rain soak into the earth?

Fill a shallow pan with soil. Sprinkle the soil with water until it will not absorb any more water. Set the pan in a larger pan and tilt it slightly. Continue to sprinkle.

What happens when more rain falls than the soil can absorb? How does gravity affect water on the surface? □ □

Water that runs off a field or a hill can make changes in the surface of the earth. In places where there is plenty of rain, running water is the main carver of the land. It wears away mountains, builds up plains, and digs out valleys. It ruins good fertile soil by dissolving minerals and washing them away. Water is always on the move, tearing down and building up the surface of the earth.





Erosion by Running Water

As running water moves from place to place, it carries along with it soil, sand, rock, and many other materials. Sharp-edged particles of soil and rock are the tools the water uses to carve the surface over which it flows.

Put a few tablespoonfuls of soil in a pint jar of water. Shake the jar. What do you notice?

Water that runs off a mountainside forms swiftly flowing streams. Just as the earth materials cannot settle in a jar that is

being shaken, they cannot settle in the fast-moving mountain streams. Rocks and pebbles, caught up by the moving water, smash against the stream beds and cut them away.

Have you ever seen a valley with a stream or small river winding through it? The valley may once have been level land as high as the hills that surround it. The earth materials that once filled the valley may have been carried away by the water, during many thousands of years.

One of the most amazing examples of erosion by a river is the Grand Canyon of the Colorado River. For 30 million years or more, the Colorado River has been cutting its way through a great mound of sedimentary rock. The canyon it has carved is 6,000 feet deep in some places.

Niagara Falls is another place where erosion is taking place. The Niagara River flows over a cliff of hard limestone and soft shale. The rock is being worn away at the rate of about five feet a year by the moving water. Would limestone and shale wear away at the same rate?



Running Water Builds Land

Running water carries soil, bits of rock, and other earth materials with it. What happens when a narrow, swift-flowing stream broadens out and flows more slowly?

INVESTIGATE

Take a cupful of soil that contains bits of rock, sand, and pebbles. Put the soil into a quart jar and fill the jar almost to the top with water. Cover the jar tightly and shake it hard. Set the jar down and watch carefully as the earth materials settle.

Which material drops to the bottom of the jar first? Which material remains floating in the water longest? What are the differences between the materials? Which of these materials will be dropped first when running water loses speed? Which materials will be carried farthest by the running water? □ □

In the foothills of mountains, streams join. Here the land is not so steep, and so the water flows more slowly and a wide river is formed. The river drops, or deposits, some of the earth materials. These materials, called sediments, gradually build up the river bed.





Two or more rivers may join together to form a river system. The largest river system in the United States is the Mississippi River System. The main river, the Mississippi, flows for more than 2,300 miles, picking up earth materials in some places and depositing them in others. When it finally reaches the quiet waters of the Gulf of Mexico, the Mississippi deposits the last of its earth materials, over a million tons a day.

Much of the Mississippi's sediment is carried farther by the Gulf waters, but much is deposited to

form a low plain where the river meets the sea. A plain that is built up at the mouth of a stream or river is called a delta. The Mississippi delta is always growing, pushing its way farther out into the Gulf of Mexico.

The Waves of the Sea

What happens where the ocean meets the land? Have you ever watched waves breaking on a beach? What changes might you see if you spent a whole summer at the beach, and returned to the same place day after day?

Ocean waves have battered away at the coastlines of the earth for hundreds of millions of years. There is constant change wherever the ocean meets the land. Sometimes the change is great and sudden, as when a single storm washes away part of an island. More often, the change is only a few grains of sand washed away.

DISCOVER

Where does sand come from? Have you ever seen stones on a beach? Most of the stones you find on a beach are smooth and rounded. What shapes these stones? What effect might the action of waves have on the shapes?



Put three or four sugar cubes in a small jar. Put the lid tightly on the jar and shake the jar for two minutes. Open the jar and examine the cubes. What has happened to the corners of the cubes? What do you find at the bottom of the jar? ☐ ☐

Waves wash up on the beach and tumble the rocks against each other. Gradually, the rocks on beaches are being broken down into sand. Of course, the change from rock to sand does not take place overnight. The ocean may change a rocky coastline to a region of soft and rolling sand dunes, but the change will take many thousands of years. Which would take longer to change, a coastline of hard rock or one of soft rock?



Water in the Earth

Rain falls on mountainsides, and runs off as a swift-moving stream. Streams join together to form broad rivers that flow through valleys and across plains to the sea. All the way, from rain to sea, the moving water is changing the surface of the earth.

Does all the rain run off the land it falls upon? Would plants be able to live if this were so? What happens to the water when you water a plant? Where does the water go? What happens to the water when you water a lawn or garden? Where does the water go? Why?

OBSERVE

Fill a sprinkling bottle with water. Place a sponge on a sheet of wax paper and sprinkle the sponge with water. Do not let any water run down the sides of the sponge. Keep sprinkling the sponge as long as the water will disappear into it. Examine the sponge. What is holding the water in the sponge?



Dip one end of a slice of bread into colored water. What happens? Why? Dip one end of a sugar cube into a spoonful of coffee. What happens? Why? □□



All the materials you used in this observation held water. Were all the materials the same? In what way were they alike?

Each of the materials you used contained many empty spaces. Materials like these are said to be porous (PAWR-us). Porous materials are able to soak up water.

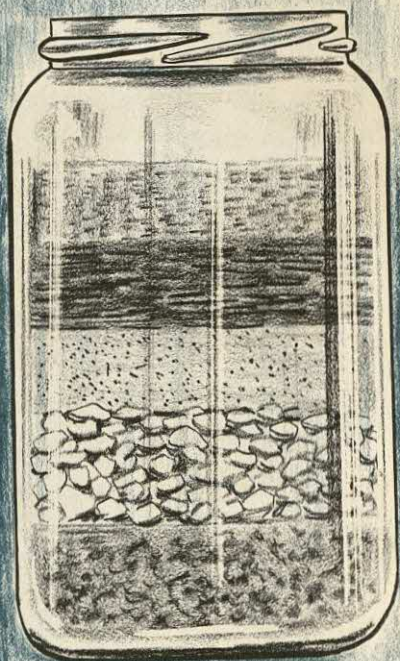
DISCOVER

Is soil porous? Does soil absorb water? Do some soils absorb more water than other soils? Can you name any other materials of the earth that absorb water?

Take a very hard rock like granite or marble and a very soft one like sandstone. Place both rocks in a jar of water. After the rocks have soaked overnight, try to wipe them dry. Is there a difference between the two rocks? Is one more difficult to dry than the other? Do all rocks absorb the same amount of water?

Fill a jar with layers of dry dirt, small pebbles or chips of rock, sand, coarse clay soil, and fine topsoil. Start with the dry dirt, as the diagram shows, and build your layers within two inches of the top of the jar. The layers in your jar are similar to the layers that make up the earth's crust.

Pour enough water onto the top layer to cover it well. Examine the jar after a few hours. What has happened to the water? Why? Add more water, but be careful not to let any water remain above the top layer of soil. What happens to rain water when it falls on the earth's surface?





EXPLAIN

Put a smooth round jar in the center of a deep pan. Fill the pan around the jar with sand. Pack down the sand and smooth out the surface. Slowly pour water on the sand until the sand is wet.

Wait a few minutes and then carefully lift the jar with a slow twisting motion. Watch the hole formed by the jar. After a short time, what begins to happen?

Where does the water come from? How does it move through the sand? How does underground water fill wells? Why do wells sometimes go dry when there is no rain for a long time?

Half-fill a glass baking dish with soil. Scoop some of the soil out of the center and pack it against the sides to form a “valley” and two “hills.” Pour water gently on the soil. Keep packing the soil so that it does not slide into the valley.

Look through the sides of the glass dish to see the water rise in the soil. What happens in the valley? How does underground water help to form rivers and streams? What may happen to rivers and streams during a drought?

Underground Erosion

Underground water dissolves some of the minerals in rocks. Gases such as oxygen and carbon dioxide, dissolved in the water, slowly eat away at the rocks. This underground erosion forms large caves in the earth. Have you ever visited a cave? If you have, describe it for the class.

DESCRIBE

Put a tablespoonful of salt in a glass of warm water. Stir the water until all the salt disappears. The water has dissolved the salt. A material that is able to dissolve others is called a solvent. Is water a solvent? What materials will dissolve in water?

Fill a glass with water and let it stand for half an hour. What do you see on the sides of the glass? Does air dissolve in water?

Some rocks contain iron. What do water and oxygen from the air do to iron? Put an iron nail or tack on a wet sponge. Leave it there for a week, adding water to the sponge when it gets dry. What happens to the tack or the nail? Try to scrape the rust away. What has happened to the metal?

Rocks that contain iron will rust. The rust weakens the rock.

Carbon dioxide in the air dissolves in water, too. It forms an acid that eats away at rocks in the earth. What happened to the piece of marble in vinegar?





Water and Temperature Change

How does temperature help water to change the earth's surface? You can find out.

MEASURE

Take several pieces of sandstone. Soak them in a jar of water overnight. The next day, place the stones in a plastic bag in the freezer of your refrigerator. Ex-

amine the bag of stones a day later. Has the sandstone changed? Fill two half-pint cartons with water. Measure them to be sure they are the same size. Put one of the cartons into the freezer until the water is frozen solid. Take the carton of ice from the freezer and compare it with the carton of water. Are the two cartons still the same size? ☐ ☐



You have learned that materials contract as they cool. Water is an exception to this rule. As water cools, it first contracts. Then, as it nears the freezing point, it expands. The expansion is so great that the ice takes up about $\frac{1}{9}$ more space than the water did.

Rocks with spaces in them can take in water. In cold weather, the water freezes and expands, causing the rocks to break and

crumble into smaller pieces. Gradually, the rocks are worn down into soil for plants.

Water does more to change the earth's surface than any other substance in nature. Can water appear in different forms? What is the water cycle? What happens to rain that falls on the earth? How does gravity help water to change the earth's surface? How does temperature help water to change the earth's surface?





Rivers of Ice

The upper slopes of most high mountain ranges, such as the Rocky Mountains, the Sierra Nevada, and the Alaska Range, are white with snow all year. The snow sometimes lies hundreds of feet deep in protected hollows on these mountains. The top surface of the snow is soft, but toward the bottom it is packed to icy hardness by the weight of the snow above. Such masses of snow and ice are called snow fields.

If all the snow does not melt away during the summers, the snow fields will grow larger each winter. When the weight of the snow-and-ice mass becomes great enough, it will begin to move downhill. A glacier is born.

Glaciers, carvers of the earth's surface, are slow-moving rivers of ice. Just how the glaciers move is not fully understood. No doubt, gravity helps the glaciers move downhill. But how do these solid, icy masses manage to turn corners

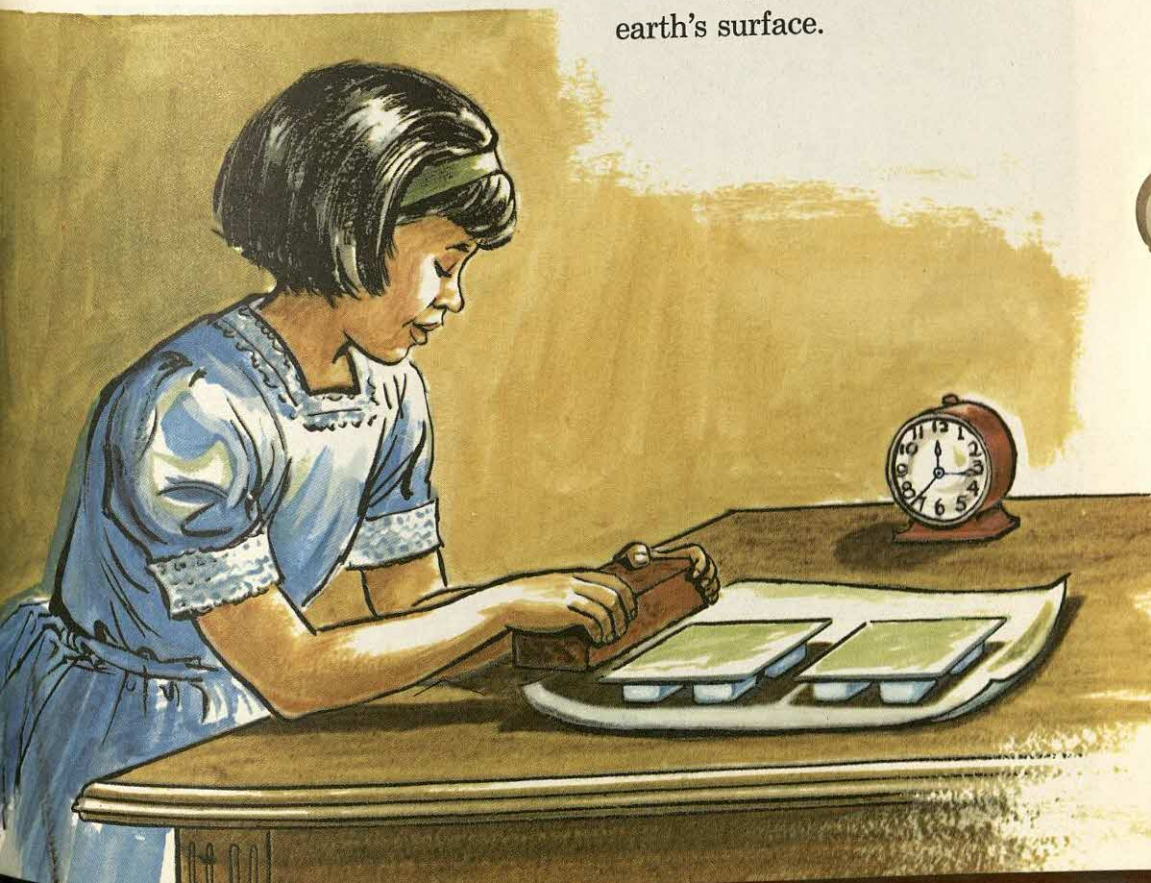
and even to creep uphill at times? Again, we do not have the answer to the question.

DISCOVER

Take a tray of ice cubes, two square pieces of cardboard, and a brick or some heavy books. On a table top, make two groups of four ice cubes each. Place a square of cardboard on top of each of the groups of cubes. Put the brick or the books on top of one of the groups of cubes. Which group of ice cubes melts faster? Does pressure have anything to do with melting? □ □

The weight of the upper layers can cause the ice at the bottom of a glacier to melt. According to one idea, a continuous process of melting, refreezing, and melting again may somehow aid the glaciers in their movements. However, the process appears to be more complicated than mere melting and refreezing.

Even though glacial movement is not completely understood, it can be measured. Some glaciers move almost 100 feet a day, others only a few inches a year. Most glacial movement is quite slow, but glaciers are still very powerful in shaping the earth's surface.



Glacial Erosion

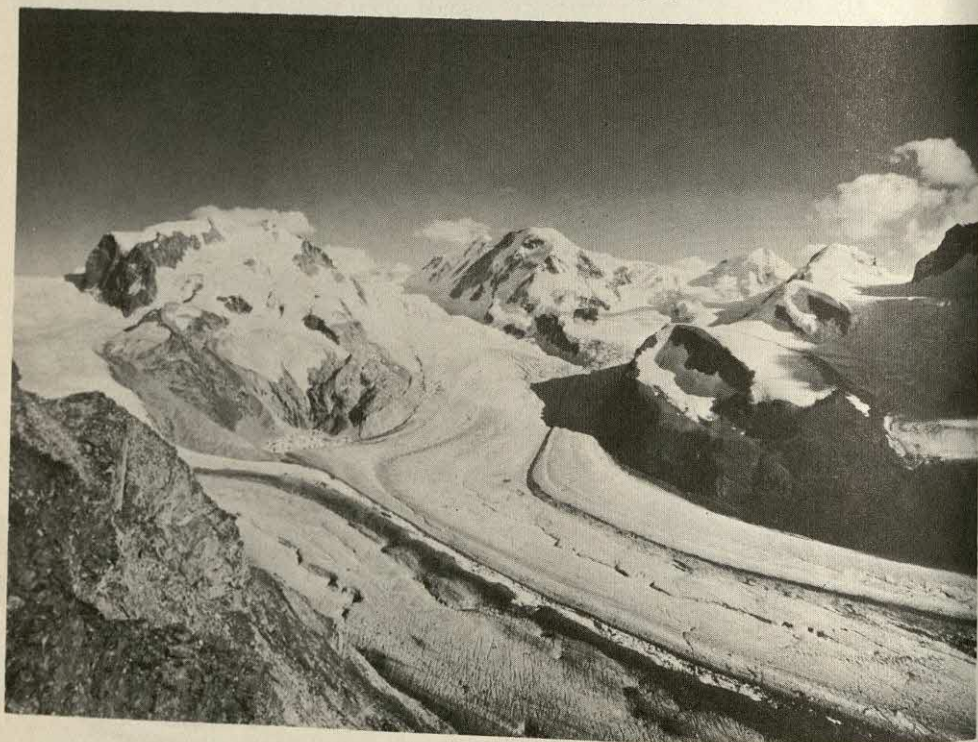
As the bottom and sides of a glacier melt and refreeze, the glacier picks up soil, sand, small rocks, and even huge boulders. These earth materials become frozen into the edges of the moving glacier. What happens when rock rubs against rock and soil?

EXPLORE

Press an ice cube into a dish of sand. When the ice cube begins to melt, put the dish and the ice cube into the freezer for an hour. Take the ice cube out of the dish and look to see if it has picked up

some of the sand. (If not, let the cube melt and refreeze again.) Rub the sandy ice on a painted board. What happens to the surface? □ □

Glaciers, bearing earth materials, grind away at the rock and soil beneath them and along their sides. They deepen and widen river valleys through which they travel. They scour and scratch the rock of mountainsides. What would you expect to see in land that was once covered by a glacier? What would you expect to find in a stream that flows from a melting glacier?





Glacial Deposits

While glaciers are always growing from their sources in the snow fields, they are always melting at their lower ends. If the glacier melts faster than it can grow, it will melt away entirely. When glaciers melt, they lay down much of their earth materials.

Earth materials that are deposited by glaciers are called drift. A melting glacier may sometimes leave a great pile of drift at the

foot of a valley. The drift acts as a dam, holding back the water from the melting glacier. As water fills the valley, a lake is formed.

Streams that flow from melting glaciers also deposit drift. While ice can carry such heavy materials as boulders, its melting water can transport only the finer, light earth materials, such as sand and soil. Often, in areas where these finer materials are deposited, large hills are formed.



The Ice Age

Several times during the past million years, North America and Europe were covered with vast sheets of ice, more than a mile thick. Many of the glaciers on the earth today are the remains of those great ice sheets.

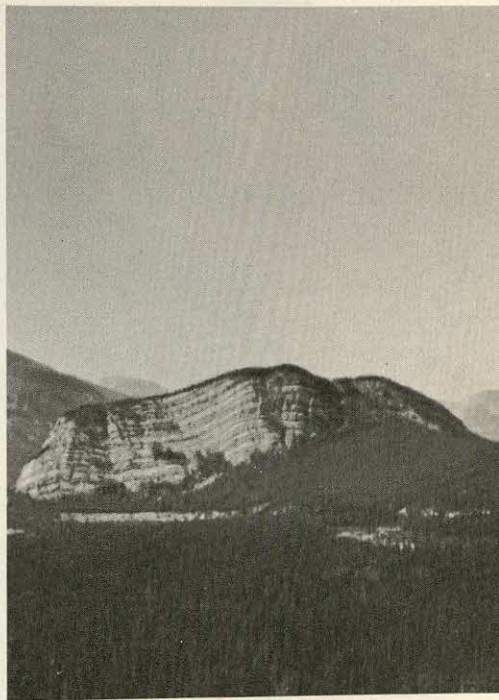
Greenland and Antarctica are still buried beneath great ice sheets called continental glaciers. These glaciers are so vast that if

they were to melt, the level of the sea would rise more than 200 feet, and many of our cities would be flooded.

Would you say that we were still in the Ice Age or that the Ice Age passed thousands of years ago? Why? Might we be at the beginning of a new Ice Age? Why? What changes might a new Ice Age make in the surface of the earth?



Mountain Building



Folded Mountains

We have talked about the wearing away of mountains by wind, water and glaciers, but where did the mountains come from? Sedimentary rocks give us many clues about the origin of mountains.

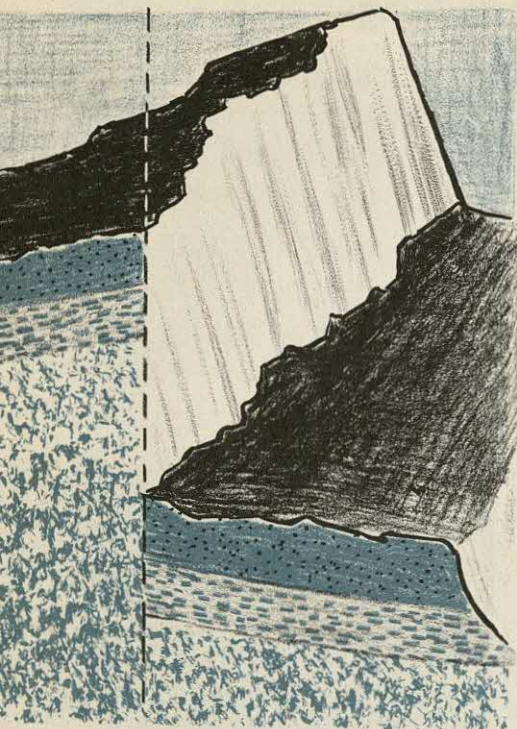
OBSERVE

Lay several pieces of different-colored blotting paper in a pile. The layers of blotting paper will represent layers of sedimentary rock. Push on the ends of the pile.

Watch one side of the pile as you push. What do you see? How is it like the sedimentary rocks in the photograph? Could you push hard enough to bend rock? □ □

Ages ago, great pressures caused the rocks of the earth's surface to bend and fold. In time, the folds of rock pushed up high enough to form mountains.

The remains of ancient sea animals have been found in the sedimentary rocks of very high mountains. What might such a discovery lead you to think?



Block Mountains

The diagram above shows another way in which mountains are made. In some places, there are deep cracks, called faults, in the earth's crust. Pressures within the earth may push up large amounts of rock along faults. Great pressures, exerted over long periods of time, may create mountains called block mountains. The weather changes their appearance, but geologists can still recognize where faults helped to build mountains.

Look for a sidewalk that has been broken by tree roots growing underneath it. You will see a tiny example of the way block mountains are formed.

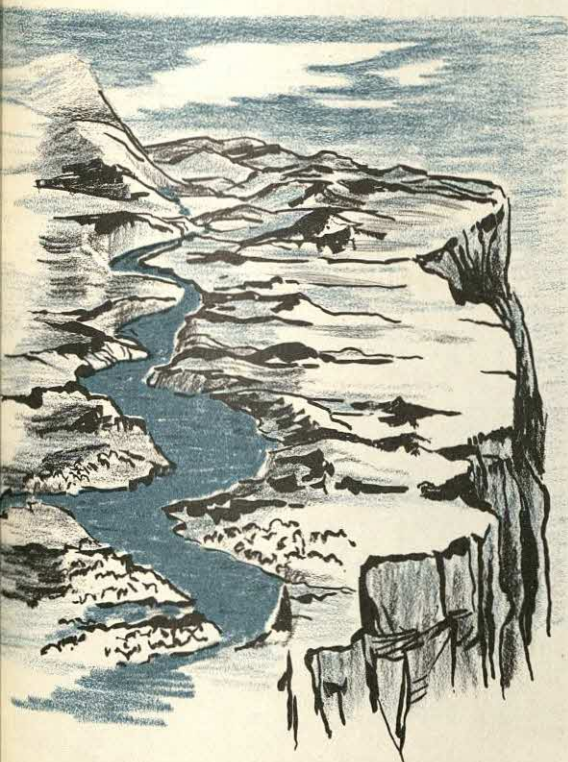
Residual Mountains

There are areas off the coast of Maine that were once dry land. They are now covered by the sea. Has the sea risen or has the land sunk? Parts of Sweden that were once on the seashore are now 900 feet above sea level. Has the sea level fallen or has the land risen?

Certain parts of the earth's crust are rising while others are sinking. We do not know what causes this movement, but we do have ideas that help to explain the rising and sinking of parts of the earth's crust. One idea suggests that the material under the crust may have a certain amount of "give" to it.

OBSERVE

Blow up a long balloon. Place it on a table. Press down on one end of the balloon. What is happening inside the balloon at the end where you press? What happens at the other end? □ □



Earth materials that are eroded from one area on the earth's surface are deposited as sediments somewhere else. Perhaps the increasing weight of sediments in one place causes it to sink, while the decreasing weight of an eroded area permits it to rise. What we have said is theory. The fact remains that different parts of the earth's surface are slowly rising and sinking.

As an area is lifted up, wind, water, and ice begin their work of erosion to sculpture the raised land into familiar mountains. Geologists call them residual (ree-zid-yoo-al) mountains.





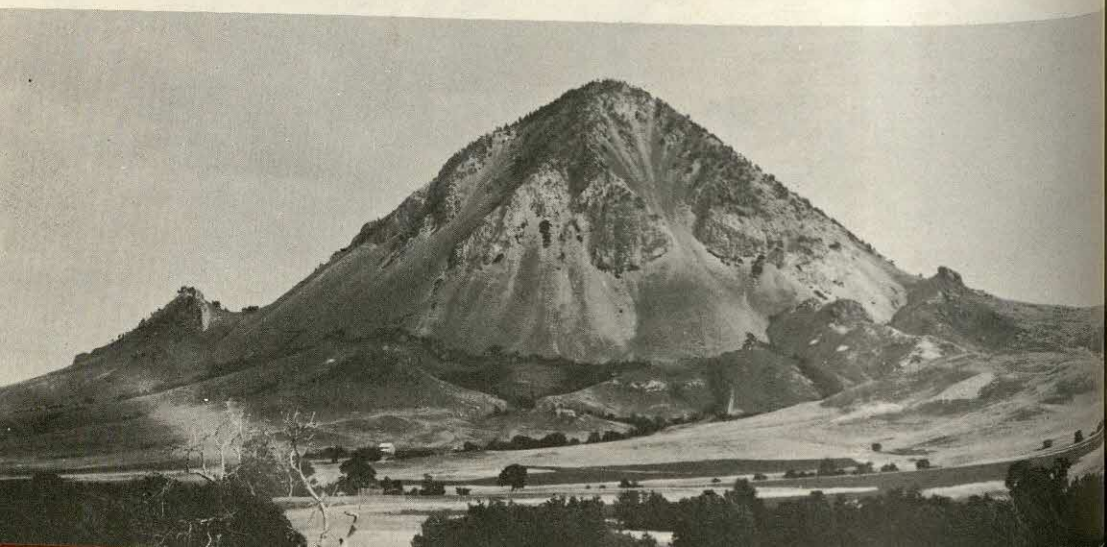
Dome Mountains

What is magma? When magma pushes its way up from deep in the earth, sometimes it breaks through the earth's crust and cools into rock on the surface of the earth. Sometimes it does not break through the crust, but cools into rock under the surface.

When magma seeps between layers of rock in the earth, it may push up the layers above it.

Mountains that are formed when magma pushes up the rock layers of the earth's crust are called dome mountains.

The rock that is formed when magma cools slowly under the surface of the earth is very hard and durable. When weathering wears away the rock layers that the magma has pushed up, we can see the igneous rock that forms the core of the mountain.



Earthquakes

Vibrations in the Earth

The changes in the earth's surface that you have studied came about slowly. There are other changes, however, that can take place suddenly and violently.

Late one Friday afternoon in 1964, the people of Alaska were going about their business. Some people were shopping, some were still at work, some were getting ready for dinner.

All of a sudden, the earth began to shake. The ground cracked,

and sections of it collapsed several feet. Buildings crumbled and fell, and cars bounced around like rubber balls.

The disturbance caused great waves in the Pacific Ocean that smashed cities along the coast of Alaska, and even in California, 2,000 miles away.

Does this seem like the kind of change that is usually made by wind, water, or ice? What caused this great change in the earth's surface?



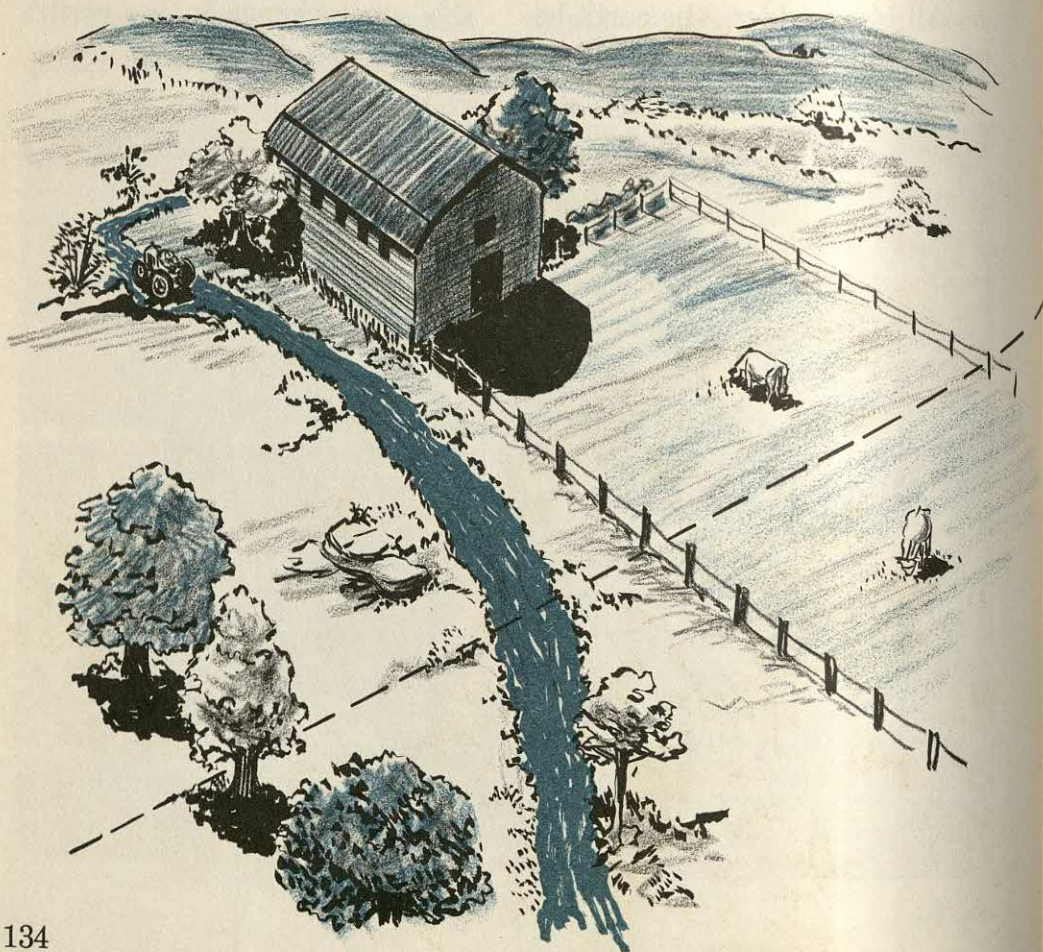
ACTIVITY

Hold a stick by the ends and bend it until it breaks. If it does not break immediately, what must you do? The stick can withstand a certain amount of force. When you exert more force than the stick can withstand, it breaks. The rocks of the earth are subject to many forces. When the forces become more than the rocks can withstand, they break and shift.

What did you feel when the ruler broke? When rocks break and shift, their movement causes vibrations. This vibration is what we call an earthquake.

Faults

Earthquakes usually occur along the deep cracks in the earth's crust that are called faults. Rocks deep in the earth's crust, on either side of the fault, are being pushed in opposite directions.



Finally, they begin to slide sideways against each other.

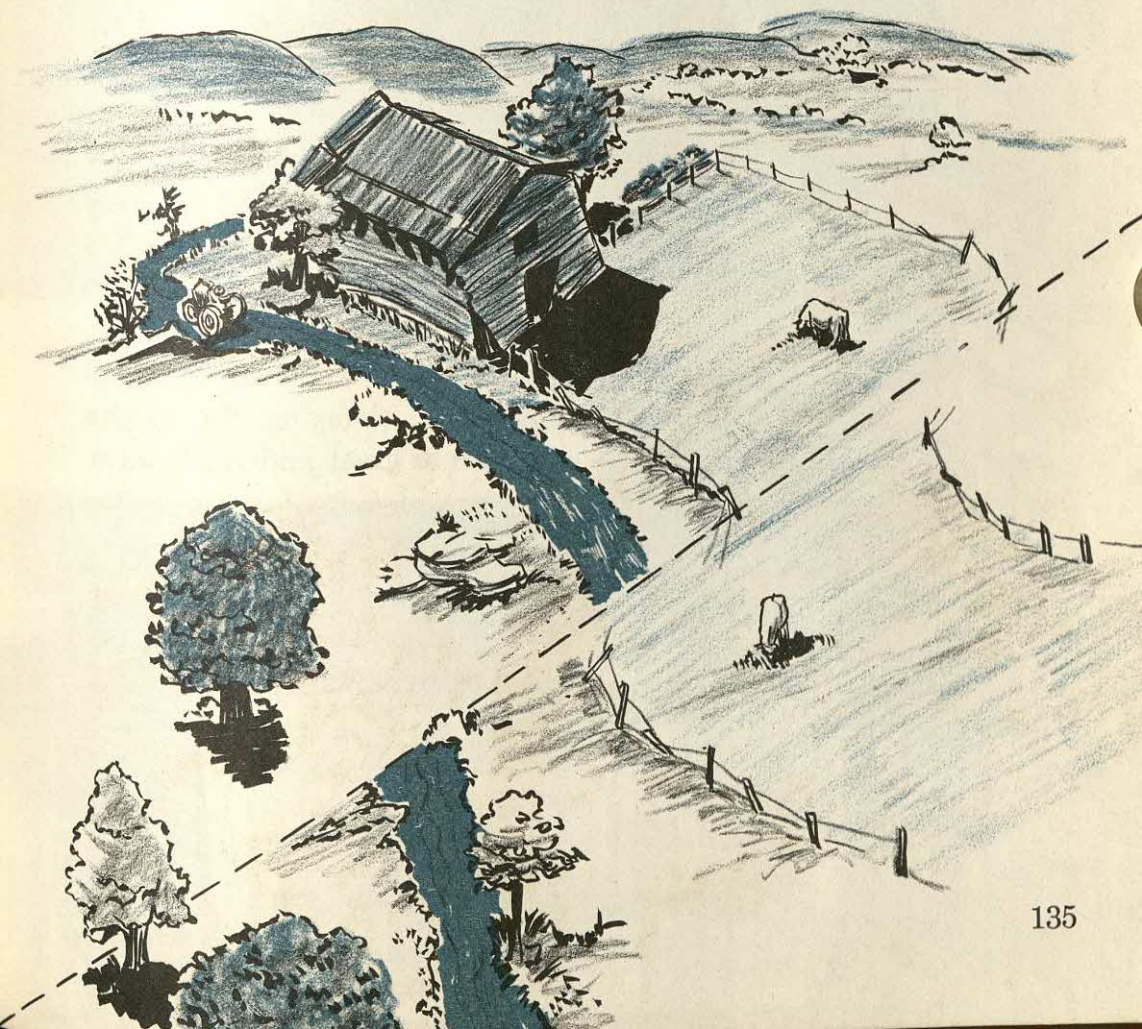
DESCRIBE

Wrap a large rock in a cloth, and break the rock with a hammer. Take two pieces of the rock and rub their edges together. What do you feel? □ □

The rough sliding movement of rocks along a fault causes vibrations that may shake the earth for many miles around.

There are two great faults in the earth's crust. One is along the Alaskan coast, and another is in California. These parts of our country are the most likely to have serious earthquakes.

Earthquakes can be caused also by large landslides and by volcanoes. Such quakes are generally not as powerful as those caused by the breaking and shifting of rocks, but they too can cause much damage.



Measuring Earthquakes

Waves of vibrations travel out in all directions from the place where an earthquake occurs. The waves can be recorded on a sensitive instrument called a seismograph (syz-mo-graf).

By studying the records made by a seismograph, scientists can learn where the earthquake is taking place and how serious it is. The numbers 1 to 10 are used to indicate the seriousness of earthquakes. The Alaskan quake of March, 1964 was measured between 8 and 9 on one such scale.

Have you ever been in an earthquake? Perhaps you have, without even knowing it. There are about 150,000 earthquakes a year, but most of them are so slight that we do not notice them. Earthquakes are happening all the time, changing the earth's surface in great and small ways.





Volcanoes

Fiery Mountains

In Hawaii, many people farm the fertile soil of the mountainside near the crater Kilauea (*kee-low-AY-a*). But when the earth begins to tremble under their feet, the people know it may soon be time to move to another part of the island. Soon, hot lava may run

down the sides of the mountain, burning and burying everything in its path. For the crater Kilauea is a volcano.

A volcano is a mountain formed by hot materials escaping from the earth's crust. Lava, steam, rocks, and hot gases may be thrown out by a volcano. The



more solid material given off by a volcano, the steeper its sides will be. Kilauea, which gives off mostly liquid lava, has gently sloping sides. Volcanoes that give off more solid material, such as ash and chunks of rock, have sides which are steeper.

ACTIVITY

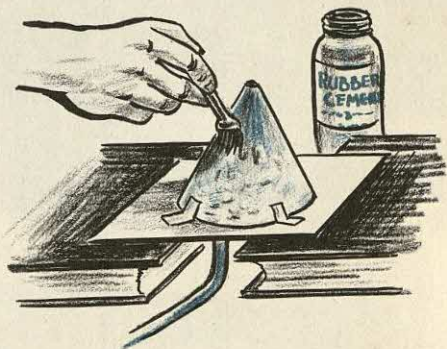
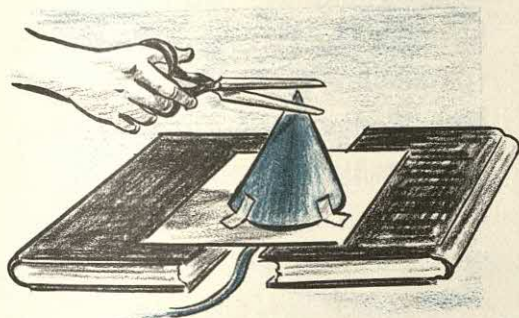
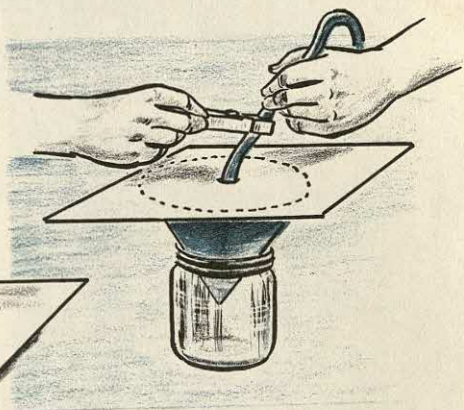
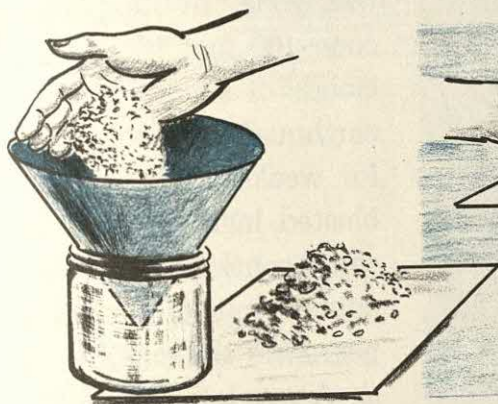
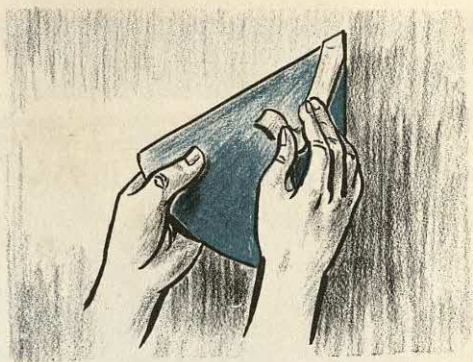
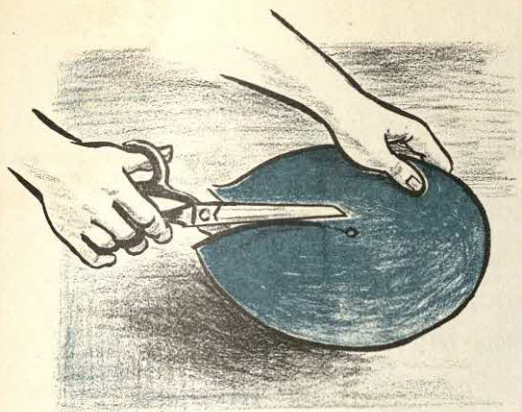
Make a model of a volcano. Take a paper circle whose diameter is 5 inches long. Cut a slit from the edge of a circle to the center and overlap the edges of the slit one inch, to form a cone. Tape the overlapped edges to hold them in position.

Set the cone upside down in the mouth of a jar. Fill the cone with grass seed, sawdust, or wood shavings from a pencil sharpener. Lay a flat piece of cardboard over the open end of the cone and tape the cone firmly to the cardboard. Make a hole in the center of the cardboard, just large enough for a piece of rubber tubing. Pinch the tubing closed with a spring-type clothespin.

Now turn the cardboard over so that the cone is on top and set it on two books, with space between them for the tubing. Cut off the tip of the cone. Coat the cone with paper cement. Blow into the rubber tubing until it is full of air. Then remove the clothespin and keep blowing.

Your model is like a volcano that has already been formed and is erupting once again. How can an eruption increase the size of a volcanic mountain?





The Birth of a Volcano

How are volcanoes formed? Not too many years ago, many people were able to watch the formation of a new volcano.



In February of 1943, a Mexican farmer was working in his cornfield when he heard a rumbling noise in the earth. A cloud of smoke rose out of a hole in the ground. The farmer hurried to town to tell his neighbors.

The next day, the cornfield was gone. In its place stood a cone 100 feet high, pouring out clouds of smoke and ash. Small earthquakes shook the ground for weeks. Rocks and ash were blasted high into the air as the cone continued to grow. Lava poured out of cracks that appeared in the earth.

A year later, the fields were destroyed and the town itself was buried. The volcano, Parícutin (pa-REE-koo-teen), was 1,500 feet high. Today Parícutin is sleeping, but it may wake again.





The Death of a Volcano

Volcanoes not only build up their cones; sometimes they destroy them. Although Parícutin was 1,500 feet high in 1944, it is 1,350 feet high today. In some of its explosions, Parícutin has blasted away part of its cone.

Krakatoa (*kra-ka-TOW-a*) was an island in the East Indies. It had begun as a volcano on the floor of the ocean, and had grown slowly till its cone towered high above the sea. In a series of eruptions in 1883, it blasted itself to pieces. The crumbled remains of the island collapsed into a great hole in the ocean bottom. A small new cone is building now where Krakatoa once stood, so there may be a repeat performance some day.

OBSERVE

Set up your cardboard and rubber tubing again. This time you will not need the paper cone. Pinch the rubber tubing closed. Make a mound of seed or shavings over the opening of the tube. Remove the clothespin. What is happening as you blow?





Lava Flows

Volcanic action is not always so exciting. Sometimes lava flows out on the surface of the earth from long cracks. This lava flows more gently than the lava that forces its way up through a small opening.

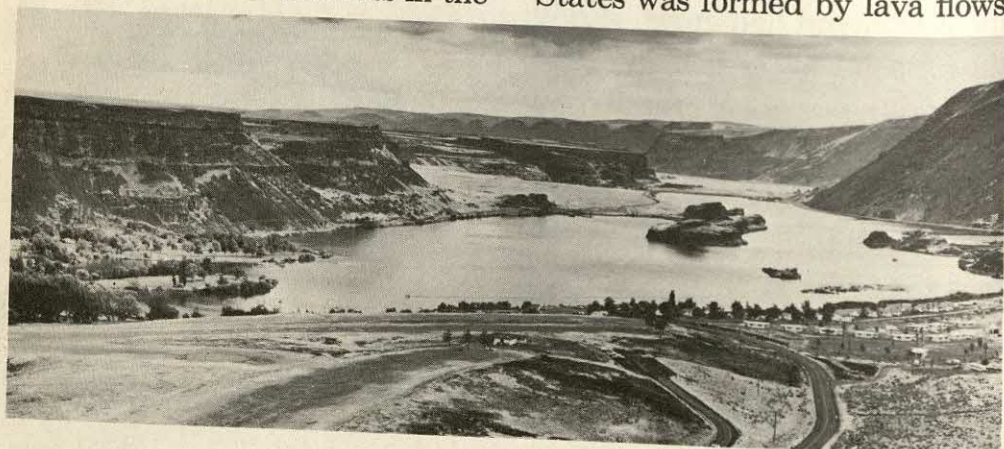
EXPLORE

Fill a cake pan with runny mud. Cut a piece of cardboard to fit the pan. Make two slits in the

cardboard, 6 inches long and $\frac{1}{4}$ inch wide. Now press the cardboard down onto the mud. What happens? □ □

Many regions of the earth have been covered by lava that flowed from such long cracks in the earth. This sort of lava flow once changed a hilly part of Iceland to a high level mound.

The Columbia and Snake River Plateau in the United States was formed by lava flows.



Volcanoes Change the Earth

The action of volcanoes builds and destroys mountains. Under-sea volcanoes build up volcanic islands and sometimes, as in the case of Krakatoa, destroy them. Lava flows change hilly regions to high flat plateaus.

Magma and lava cool to form igneous rocks. What igneous rocks do you know of? Volcanic ash hardens to form a rock called tuff.

What happens to the hardened lava and ash after a volcano has stopped erupting? What do wind and water do to these volcanic materials? How do temperature

changes affect them? The soil that later forms from tiny pieces of volcanic material is very fertile. It makes excellent farmland.

Volcanoes also give off water vapor and carbon dioxide. In the early days of the earth, the water vapor given off by volcanoes helped to fill the oceans. Without carbon dioxide in the atmosphere, plants could not live. How do plants use carbon dioxide? How do we use plants?

Although volcanoes can cause great destruction, they have helped to make the earth suitable for living things.



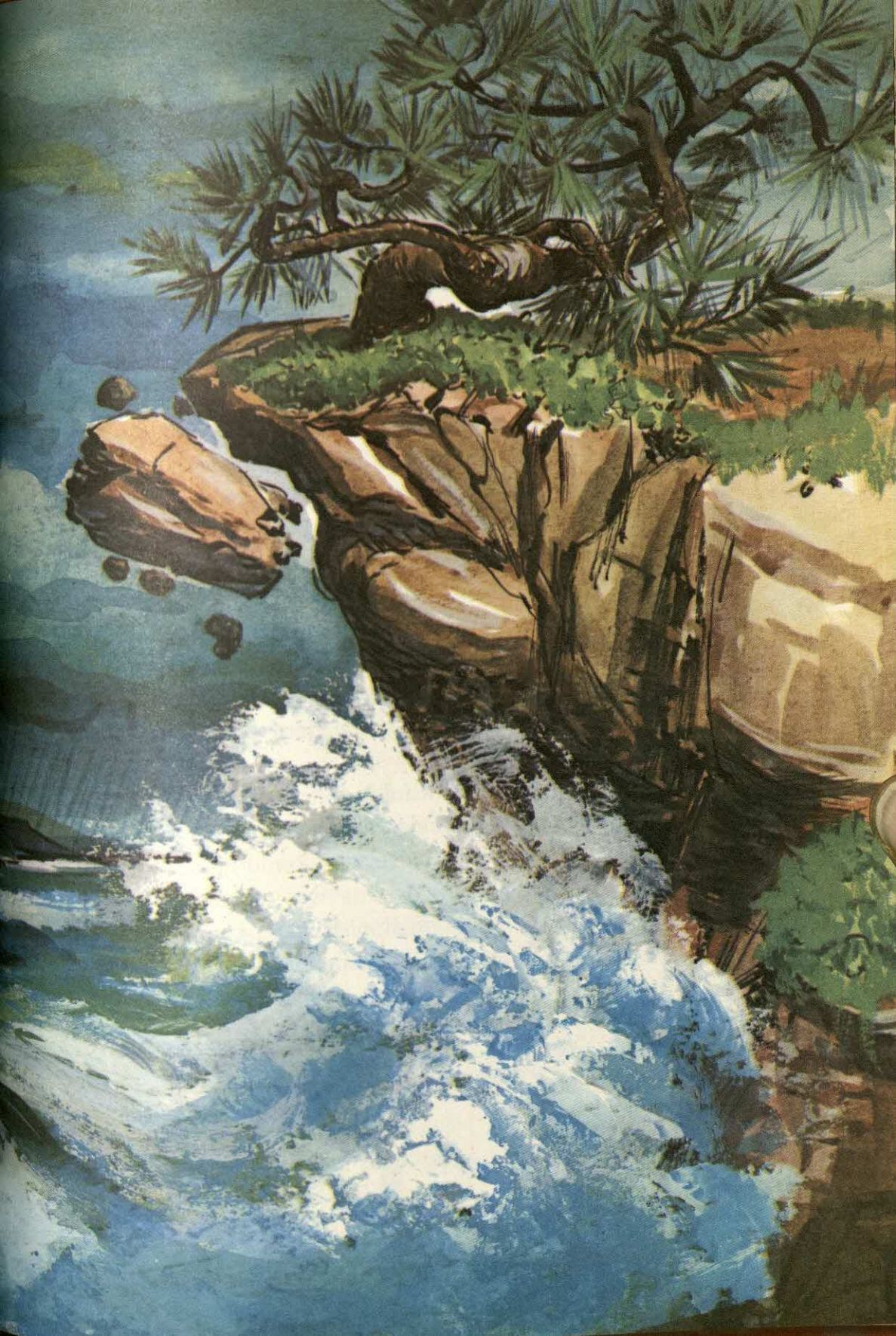
Time and Change

The age of the earth is figured in billions of years. The landscape you see today is only a moment in the long history of the changing earth.

The ocean waves may plunge great cliffs into the sea overnight. A volcano may build a high mountain in a week or a month. But most changes in the earth's surface come about gradually, during hundreds or thousands or millions of years.

Ages from now, there may be high mountains where you see only hills today. The great mountain ranges of the earth today may vanish ten million years from now. As time passes, the surface of the earth is built up in some areas and worn down in others. Tell what you know about the changing surface of the earth.







THINK

Explain how each of the following affects the earth's surface: glaciers, water, wind, temperature.

What is the relationship between cave development and the weathering process?

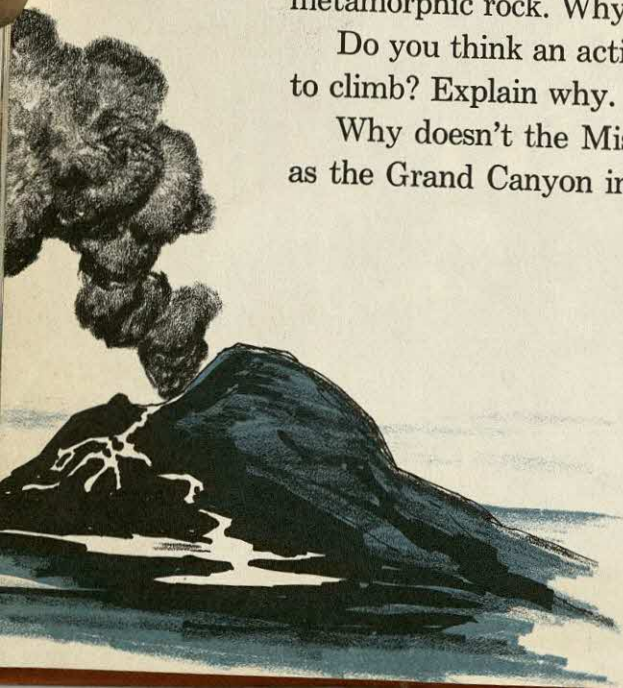
What might determine how much of a shock you feel if an earthquake occurs somewhere on the earth?

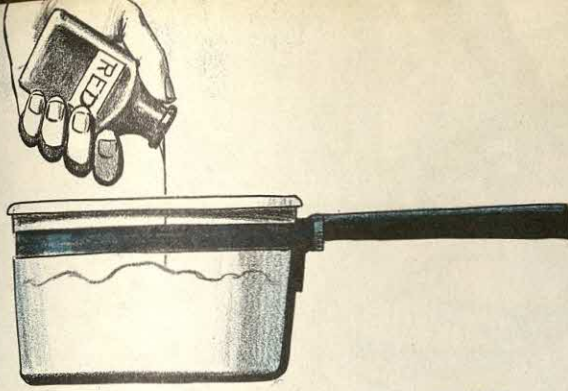
Geologists are spending a great deal of time trying to find out the causes of earthquakes. What are some of the difficulties which prevent them from predicting where earthquakes will occur?

Fossils are more plentiful in sedimentary rock than in metamorphic rock. Why do you think this is so?

Do you think an active volcano would be hard or easy to climb? Explain why.

Why doesn't the Mississippi River cut a canyon such as the Grand Canyon in Colorado?





PROJECTS

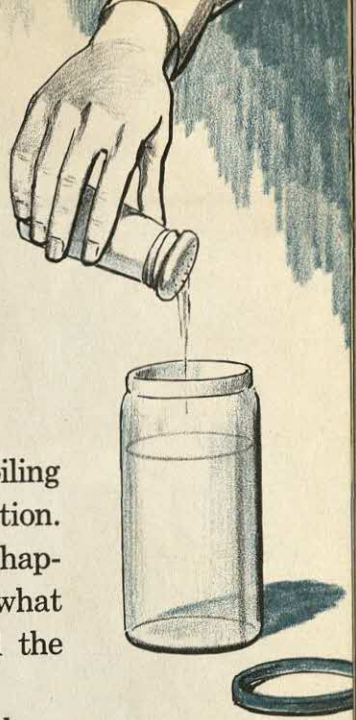
Pour some red and orange dye into a pot of boiling cream of wheat. Stir and observe the bubbling action. Turn off the heat and allow the pot to cool. What happens to the surface of the cream of wheat? How does what you observe demonstrate what some scientists feel the surface of the earth was like many years ago?

Prepare a report on some famous volcanoes such as Vesuvius, Parícutin, Fujisan.

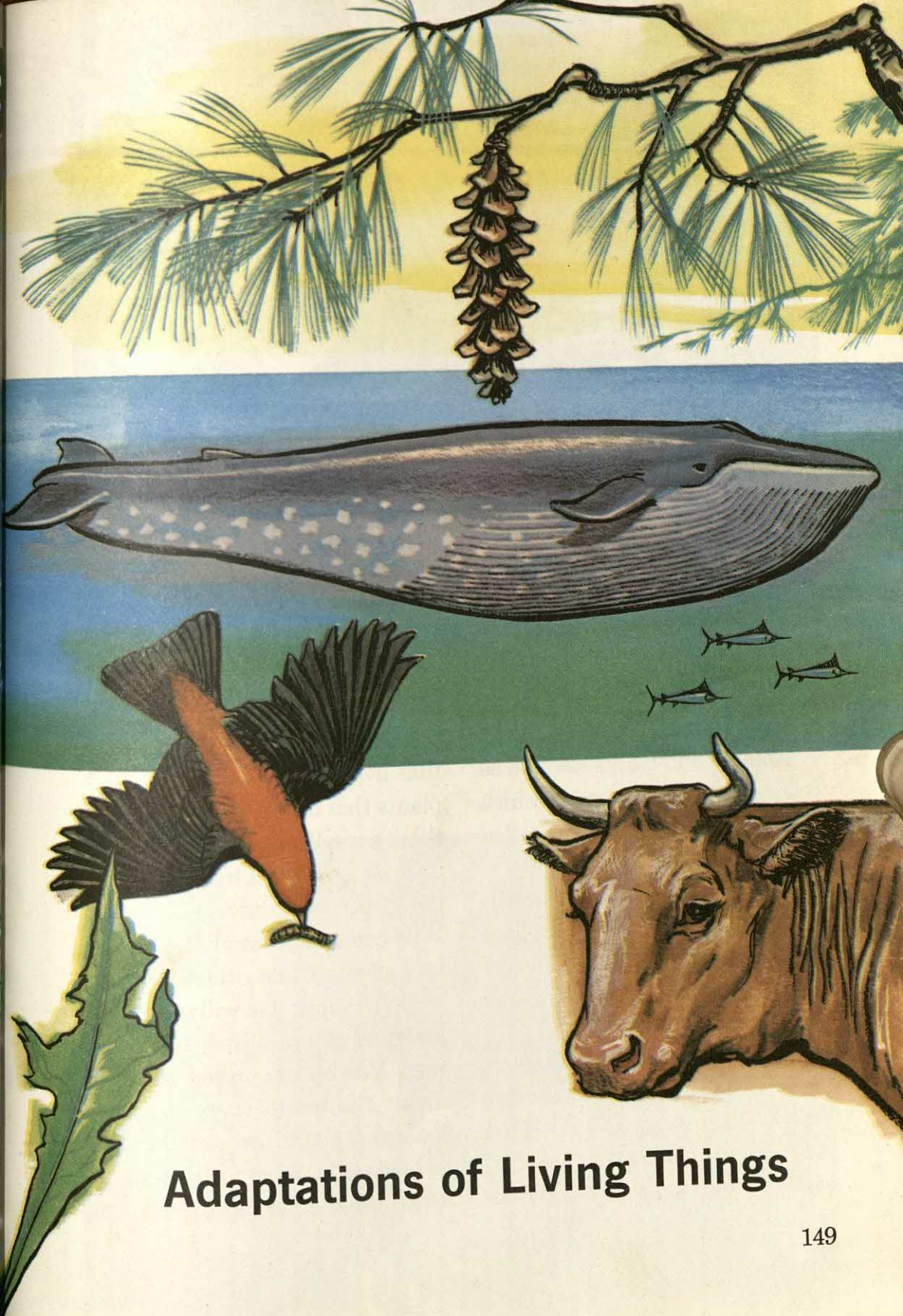
Put a small amount of salt in a jar of water. Shake it. What happens to the salt? Add several more spoonfuls of salt until it begins to settle on the bottom of the jar. Pour the salt water into a shallow pan and place the pan on a sunny window ledge. Let the water evaporate naturally. What happens? Where on the earth's surface would you find such salt deposits from sea water?

Make a mixture of sediments ranging in size from clay to coarse sand. Set several shallow pans at different distances from an electric fan. Do this experiment outdoors. Turn the fan on at slow speed and pour a small stream of the mixture slowly in front of the fan. Observe what is collected in the pans. Is there a pattern? Repeat the experiment with different fan speeds. Does the strength of the wind make any difference? How might sediments be moved by the wind on the earth's surface?

Locate different types of erosion near your home. Make a map to show what you have found.







Adaptations of Living Things



Animals and plants seem to be well suited to the places in which they live. These places are called their habitats (HAB-i-tats).

Many animals and plants must live in special habitats where they can obtain food and water, where they can protect themselves, and where they can reproduce.

Some animals are most at home in forests, while others are most at home in open fields. What plants and animals would you find on a desert? Name some animals

that live only in water. Are there plants that live in the sea? Do you think a giraffe would eat the same food as a tiger? Why? Why does the polar bear have white fur? Why can some animals live in very cold places while others cannot?

In this unit you will study animals and plants in their surroundings. You will be asked to think about the many ways that animals and plants are suited to live in fields or in woods, on mountains or on deserts, and in fresh water.

Habitats of Living Things

Living Things Nearby

If you begin your study of living things and their surroundings in a field near your home or your school, you may see many wild flowers and grasses. Often these wild flowers are called weeds. What is a weed? Why are some flowers called weeds?

A rabbit may hop quickly through the grass and then stop to eat. What does a rabbit eat? There will be food or shelter for each kind of animal you find in the field. Under an upturned stone you may see fat, white worm-like animals called grubs. These are the young beetles. A robin will be glad to make a meal of them. New-

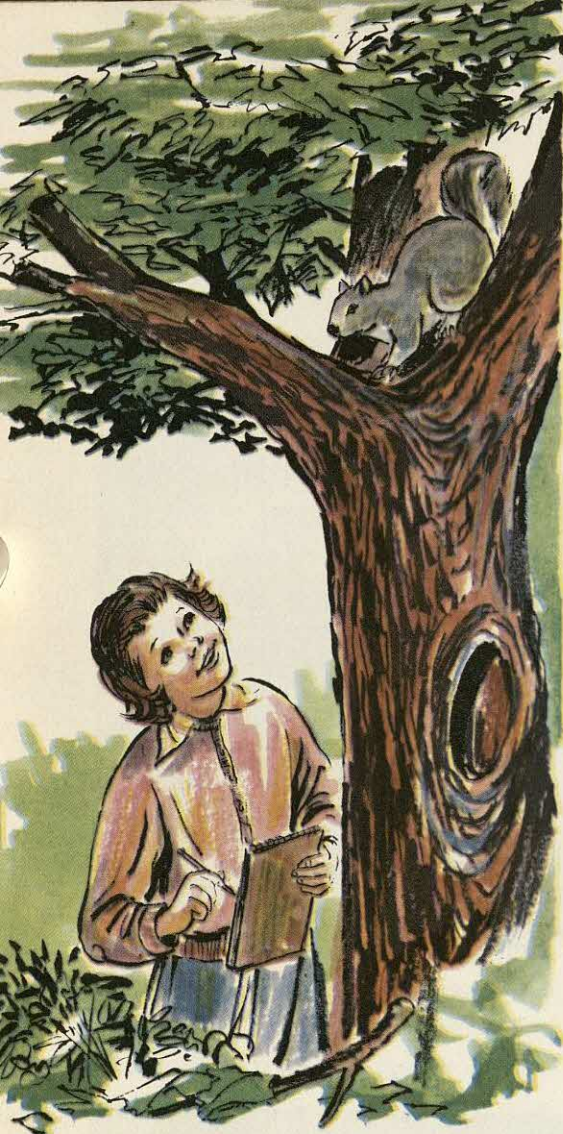
ly-hatched grasshoppers, called nymphs (NIMFS), may be chewing on the leaves of shrubs. Do you know how these nymphs differ from the adult grasshoppers? Do you know why meadowlarks are seen in open fields?

OBSERVE

If there is time during your science period, identify and count the animals and plants in your schoolyard. Before you go out into the yard, you need to be organized into teams, and to decide what each team will look for.

Several animals can be assigned to each team. There may be insects, spiders, sparrows,





toads, squirrels, cats, chipmunks, rabbits and many other animals in your schoolyard. Other teams will look for plants, such as trees, shrubs, grasses, ferns, and mosses. The captain of each team will record the name and number of animals or plants that his team finds.

On your next field trip you could select one animal for study.

One of the most common animals around many schoolyards or homes is the grey squirrel. So many generations of these furry animals have lived in city parks that many of them are almost as tame as cats or dogs. Even if the park squirrels were not fed peanuts and popcorn, they would not go hungry, for they are well suited to finding the food they need. The long front teeth of the squirrel have chisel-like edges that can cut easily through the tough shells of wild nuts and seeds. Squirrels also eat bits of tree bark and berries. They will raid the nests of birds for eggs that are left unprotected.

If you see a squirrel, watch to see what food it is collecting or eating. Watch it climb a tree. Could you climb a tree that fast? How do the sharp claws help the squirrel? What use to the squirrel is its bushy tail?

You may want to observe a bird, a kitten, or some other animal. Write down the observations you make of the animal you select for study. Describe the size, shape, and color of the animal. How many legs does it have? What food does it eat? Where does it spend most of its time?



INVESTIGATE

A field or woodland terrarium in the classroom is a good place for observing the habits of some small animals. An empty fish tank will make a good container. Put a layer of pebbles about an inch deep in the bottom. Place a half-inch layer of sand over the pebbles. Finish with an inch of rich garden soil.

It will be best to collect your plants from a wooded area. You can get low-growing plants like ferns, mosses, and other small plants. When you dig up ferns or mosses, leave some of the soil around the roots. Keep the plants moist until you have planted them in the terrarium.

Water your terrarium well. The water level should be about halfway up the layer of pebbles. If you keep your terrarium covered with a glass plate, the plants will have the moisture they need, and will not have to be watered very often.

Your terrarium is now ready for some animals. A toad is an interesting animal to observe. The boy in the picture is feeding earthworms to the toad. The toad has a long tongue attached at the front of its mouth. A toad's tongue is sticky. How does the toad use its long sticky tongue? How can you find out?

You may want to get other animals for your terrarium.



Animals and Plants on the Mountain

Have you ever climbed or driven up a high mountain, such as one of the great western mountains? How did you feel as you went up the mountain? Perhaps you will remember that as you traveled higher and higher, the temperature got lower and lower. Did you observe regions of different colors as you climbed?

If you stand at the bottom of a high mountain and look up, you

will see regions of different colors, such as several shades of green, brown, and gray. Some of the highest mountains in North America are white on the top, because they are snowcapped. The snow does not melt even in the summertime. When you travel up such a mountain, you see that the colors mark off different parts or zones of the mountain. How do you think the different climates affect the plants and animals on the mountain?

At the foot of the mountain, there may be fields with plenty of green grass. Forests of green trees may surround the fields at the bottom of the mountain. Chipmunks and rabbits may be running about looking for food. The forest may have many kinds of animals.

Heavy black oak trees, pines, and other evergreens may account for the green on the lower slopes of the mountain. Mountain bluebirds fly through the trees, and quail may be on the ground.

Higher up the mountain, the deeper green color that you saw from the bottom of the mountain is made by tall evergreen trees that look like Christmas trees. Large pine cones are scattered over the ground. Gophers run out of their burrows. A pool of water fed by a mountain stream may contain different kinds of fish. Black and brown bears on this part of the mountain may catch a fish for their next meal, or they may eat berries or nuts.

Farther on, there are rugged cliffs. Growing in the cracks of the rocks are small plants. Why might these plants have long thin roots? Mountain goats live on

this rocky land. Why do you think they have such small feet? There are only a few trees on this part of the mountain. The trees are short and their trunks are twisted.

Above a certain height on the mountain, no trees will grow. There is a definite line where the trees end, called the timberline. From the timberline to the top of the mountain, the rocky slopes are often covered with snow. But there are animals that live even on this part of the mountain. Small birds called finches eat insects and seeds that the wind



blows onto the snow. Other birds, such as the mountain chickadee and the junco in the Rockies, nest at the tops of the mountains. In wintertime, they move down.

RECORD

Make a list of the animals and plants you would be likely to see if you traveled up a peak in the Rocky Mountains. Which ones would you expect to see at the foot of the mountain? Which animals live at the top? Why are different

animals and plants found on different levels?

Living Things at the Far North

The climate of the North Polar region is much like that at the top of a high mountain. But there are animals at this polar region that you would not find on a mountain.

The largest land animals of the region are the polar bears. Polar bears live on ice the year round, but they are well fitted for



living in such a cold land. Their coats of fur are very thick. They have a layer of fat under the skin which also helps to keep in the heat of their bodies. What do we use instead of fur and a layer of fat to keep us warm?

Polar bears are good swimmers and can swim in the cold arctic waters. Their heavy coats of oily fur and the fat under their skins enable polar bears to withstand the freezing temperatures. The polar bear can walk over ice without slipping because it has heavy pads of fur on the soles of its feet.

INVESTIGATE

Bring to class a cardboard box. Paint the inside of the box the color of a particular habitat. For example, if you want to show the north pole region, paint it white, the color of snow. If you want to show a plain area, draw in grasses and sky.

Now cut paper animals and color them so that they will blend in with the background. How does the color of an animal help it in its environment? ☐ ☐

Why do you think most polar bears are white? How does this color help the polar bear? The



polar bear lives mostly on seals and fish, but also eats birds and foxes. Some of these animals are as white as the bear. The arctic foxes are white. The ptarmigan (TAR-mi-gan), an arctic bird, is white during the winter, but gets brown feathers in the spring. Food is scarce in winter at this polar region, so meat-eating animals must be skillful hunters.

There are no trees at the North Pole, but there are some familiar plants growing there. For example, mosses and lichens can grow in the arctic regions.

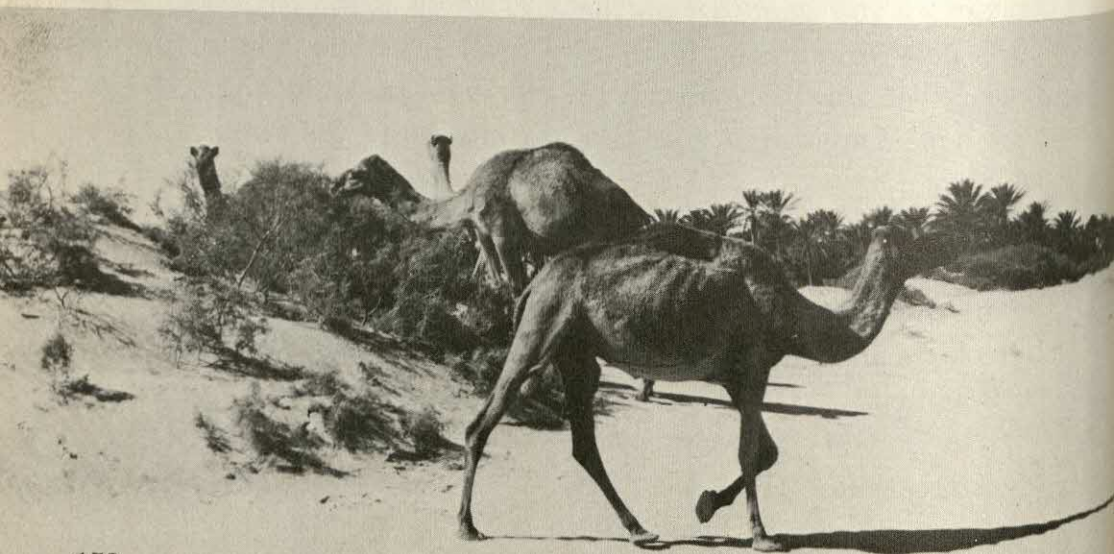
Desert Life

Many of the animals and plants that live on the desert are very different from those that live at the North Pole, in the mountains, or in fields. All living things must have water to survive. Deserts have very little rainfall, so the desert animals and plants must have special ways of finding and saving water.

Camels are very valuable animals in the desert. They are able to go without water for long periods of time. Find out how long a camel can go without water. A thirsty camel may drink 20 gallons of water at one time. The camel can store this water in its muscles. Try to find out what is stored in the hump on the back of the camel.

A North American cactus, the spiny prickly pear, now grows in the deserts of North Africa and is eaten by camels. The stems of this plant are enlarged and have tissue that can hold much water. Camels sometimes get water, as well as food, from such plants. What type of roots would these plants have?

The large, spongy, and flat hoofs of the camel make it easy for the animal to walk over the soft hills of sand. How do the very long legs of the camel help it? The camel has long thick eyelashes, and slit-shaped nostrils that can be closed tightly. Of what use would these be to a camel in a sandstorm? Would a horse be as useful as a camel to man in the desert?





The best known North American desert animal is the coyote (KY-ohT). This handsome wolf-like animal is a good hunter. It will eat rabbits, mice, ground squirrels, lizards, snakes, birds, or insects. On the desert, it may also live on cactus and the beans of the mesquite (mes-KEET) plant.

Collared lizards live in rocky areas. They feed on insects and smaller lizards.

The mesquite, like the cactus, is specially suited to desert life. Mesquite plants in Death Valley, California, have roots 30 to 100 feet long. Why do you think the roots grow so deep? How do the long roots of some desert plants help the coyote and other desert animals?

DESCRIBE

List as many animals as you can that live on the deserts of North America. What plants are found on the desert? How is each plant and animal fitted to survive in this hot, dry climate?

If you can get a few small cactus plants, some sand, and a large fishbowl, you can make a desert terrarium. Put a layer of garden soil into the fishbowl before you add the sand. A horned toad will be a suitable animal for your terrarium. Is the horned toad an amphibian? The cactus will not need to be watered more than once a week. A small pan of water and some ants or other insects will take care of the needs of your horned toad.



Underground Homes

Some animals live in underground burrows and dens. Foxes, wolves, skunks, coyotes, and prairie dogs are among the animals that make their homes underground. Even an owl may nest in the empty burrow of a fox or skunk. On the desert, burrowing animals may live underground during the hot day and come out for food at night. What are some other reasons why animals have underground homes?

The fox is a good digger and may make its den as deep as 10 feet underground. Here the cubs are born. The den has a storage room and a lookout place. Why must the fox look for animals?

Among the more unusual underground homes is that of the ants. There are so many skilled workers among the ants that they can have homes with many rooms that are connected by tunnels. Some ants build roads and tunnels. Some are like woodworkers and can carve passages through wood.

Other ants are like farmers. Some of them grow plants to feed the colony. Some ants milk plant sap from insects called aphids (AY-fids). Aphids suck the sap from plants. When an ant strokes an aphid, the aphid gives the ant a drop of plant sap in a form called honeydew.





OBSERVE

If you want to observe ants in their colony, get a shovel and a gallon jar, and begin to dig around an ant hill. Fill half the jar with loose dirt. Dig at least a foot deep into the side of an ant hill. Scoop up the dirt and pick out the ants and their eggs. If you see a very large ant, be sure to capture it for your colony. This is the queen. Put the ants and the eggs into the jar. Cover the jar with a cloth. A rubber band will hold the cloth.

Keep out sunlight from the bottom half of the jar by wrapping heavy black cloth or paper around the jar. The ants will then build their tunnels against the side of the jar. Each day, unwrap the jar and observe the ants.

Crumbs of food and occasional drops of water are the only items needed now. Put a small piece of candy in the jar. How long is it before the first ant finds the candy? How long before the second finds the candy? Do you think ants tell each other about food in the jar?

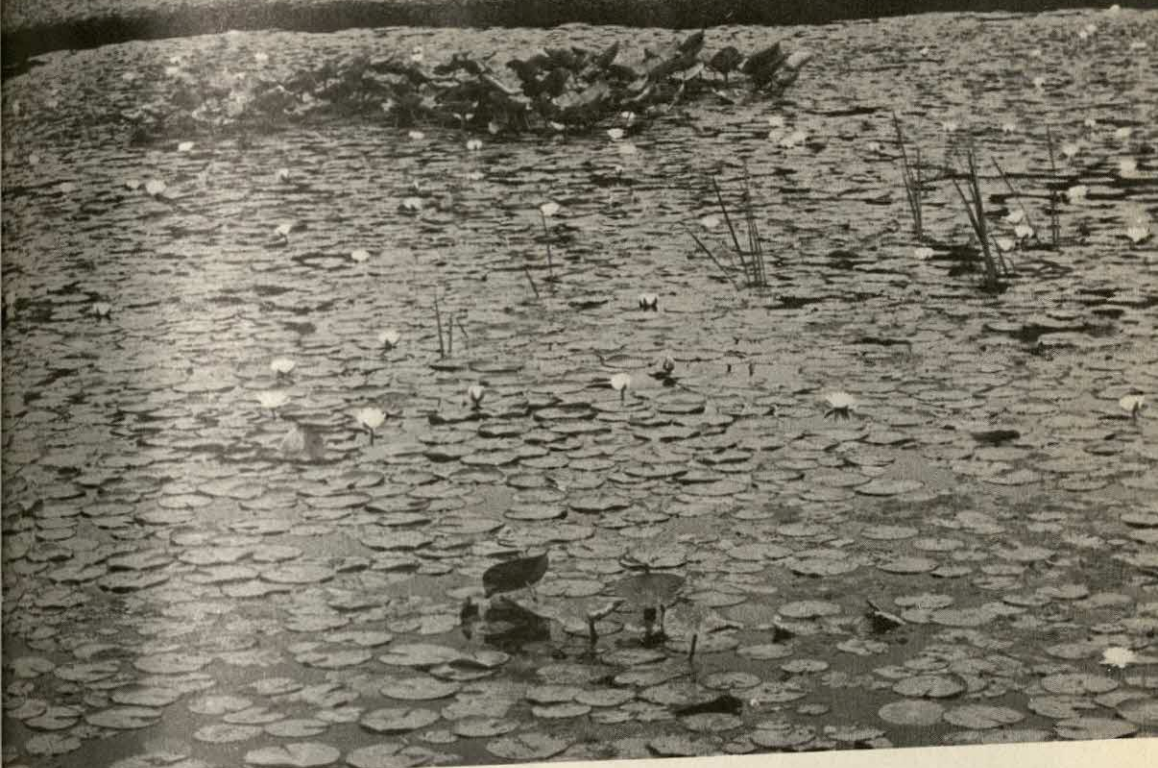
Living Things in Fresh Water

If you live near a fresh water pond or a small stream, you will be able to observe and study hundreds of living things. Each time you go exploring you will discover something interesting and new. Have you ever explored a pond? The kinds of plants and animals you discover will depend on the size of the pond, its location, its depth, and many other conditions. You may find animals and plants that are different from those your classmates find in other ponds.

An ordinary pond is a small body of water fed by a small stream or a spring. Most ponds are not very deep. Their edges are overgrown by plants whose roots grow in the moist soil or mud. As you may know, some plants grow in the water at the pond's edge. Still other plants are able to grow on and beneath the surface of the pond.

The time of year you decide to visit a pond is important too, for pond life is always changing with the seasons.





A favorable time to explore a pond is in the spring when the activities of life are most noticeable. In many parts of the United States, the first sign of spring is the appearance of the skunk cabbage along the banks of ponds and streams. In the shallows of ponds, cattails and other plants rise out of the water where their roots are anchored in the muddy bottom. Can you discover which of the plants in a pond are cattails? Farther out from the shore, duck weeds and pond lilies are floating on the water's surface.

In ponds, there are many places for animals to hide, and many sources of food. Water lilies, rushes, reeds, and other plants make hiding places for tadpoles, salamanders, and adult and young insects that are searching for food. All these pond dwellers are carrying on a battle to stay alive. In trying to obtain food, many animals are in danger of being eaten themselves.

Pond life can also be affected by cold rain, periods of dry weather, chemicals in the water, and changes of season. Tell some

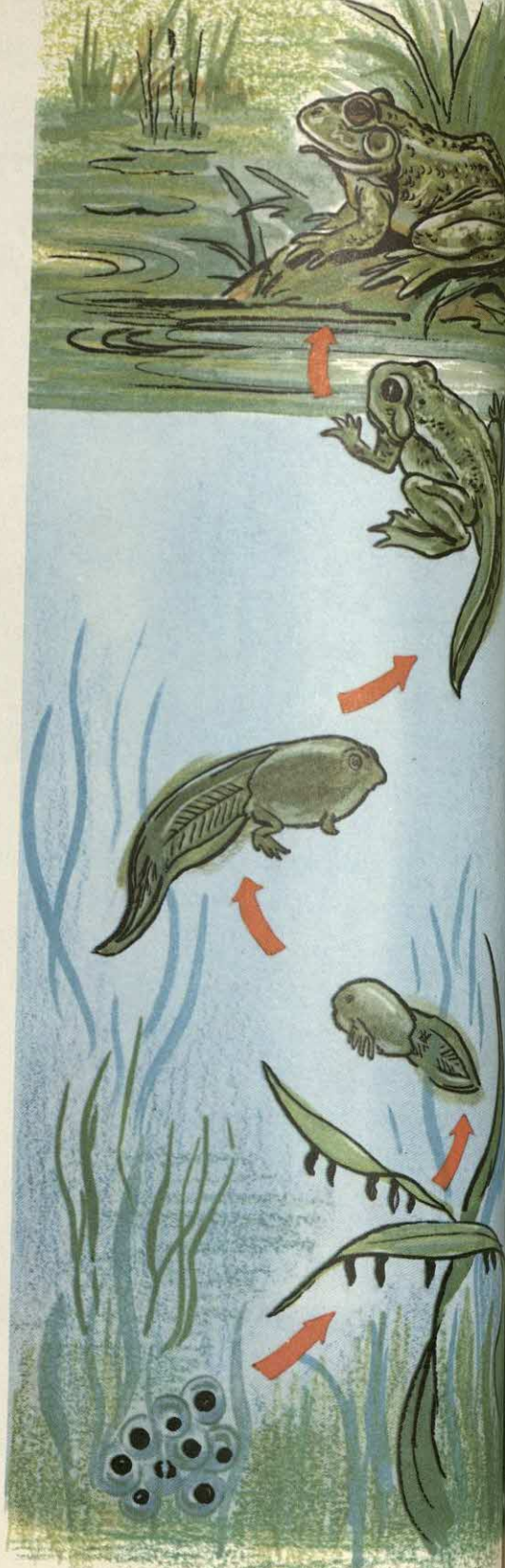
of the ways in which changes of season might affect pond life.

STUDY

You may want to study some pond animals in the classroom. A strainer from the kitchen makes an excellent dip net to catch some of these small animals. Go to a nearby pond or lake. Dip into the water among the plants near the shore. Some of the animals will be hiding in the mud near the roots of the plants. The mud will go through the strainer. Put the animals in a tin can with a little water from the pond. Try to identify them from pictures of pond animals that you may find in a library book. □ □

When you walk along the shore of almost any pond in spring or summer, you can hear and see frogs splashing into the water. Some pond frogs have bright green heads and darker green backs. Their bellies are white, and the throats of the male frogs are often bright yellow.

Bullfrogs play an important part in the drama of pond life. Like many other pond animals, frogs go through many body changes during their lives. Frogs



begin their lives as eggs covered with a jelly-like coat. You can find these eggs among the water plants of the pond in the spring or early summer. The dark spots in the jelly mass are frog eggs from which tadpoles will hatch.

During their early lives, tadpoles live like fish. They have gills and can get the oxygen they need from the water. In the next few weeks the tadpoles will grow legs, develop lungs, and gradually lose their tails. Thus they become frogs.

When frogs are in the tadpole stage of their lives, they feed on small plants and algae. They are called vegetarians because they eat only plants. If you can catch some tadpoles and bring them into the classroom, you can observe what they eat. Be sure there are water plants in your aquarium. Tadpoles will also eat little pieces of lettuce.

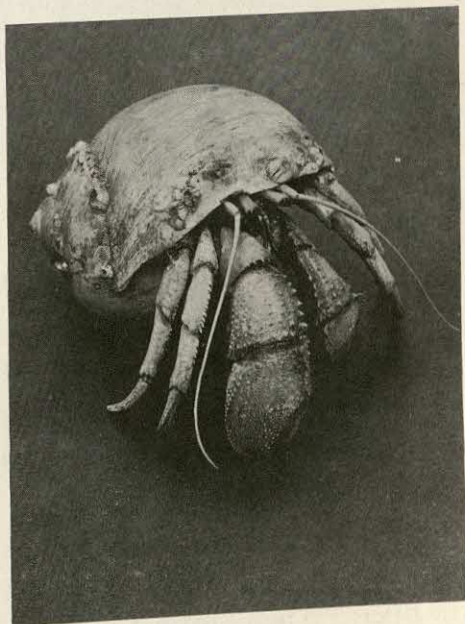
If you put some of your tadpoles in an aquarium with bigger fish, what do you think will happen to the tadpoles? Try to find out what will happen.

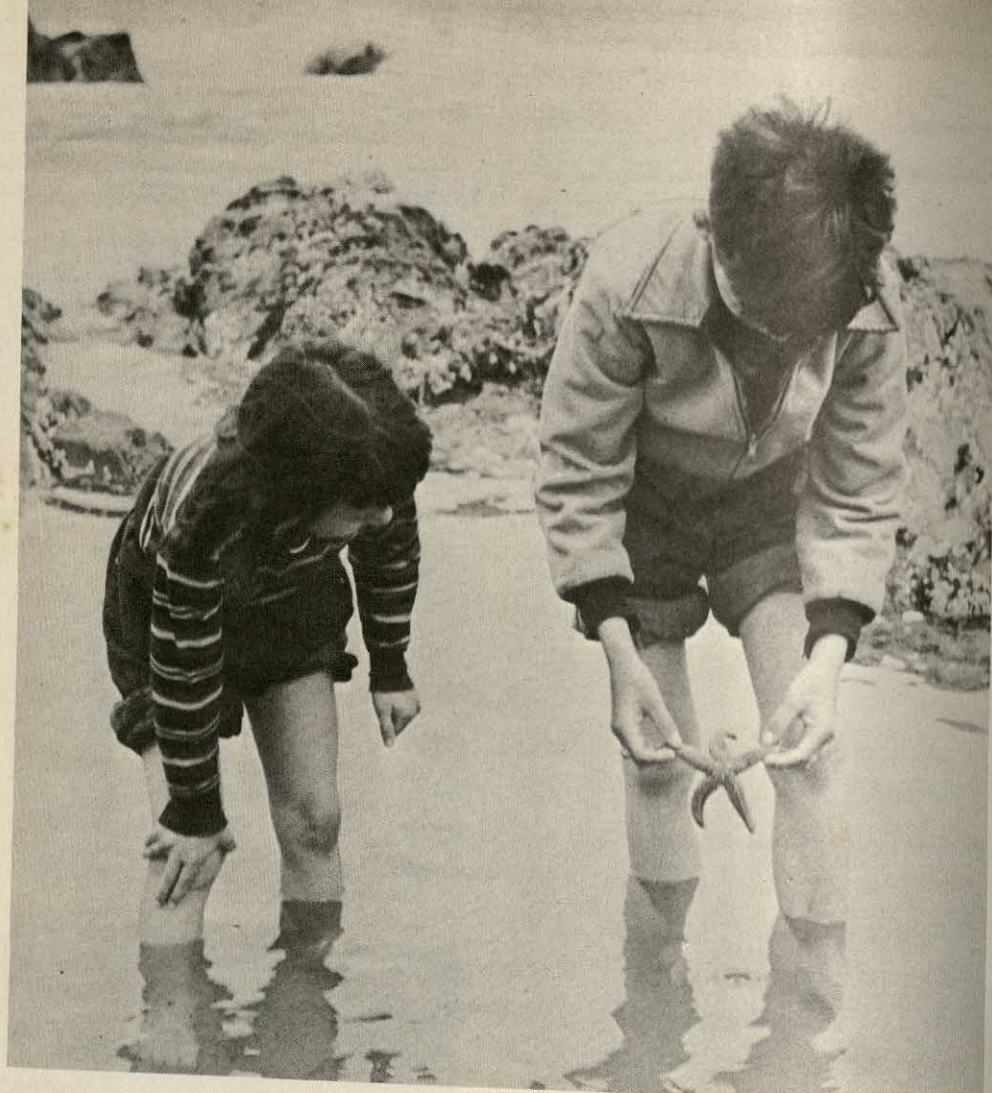
As the tadpoles grow larger, their diet changes. Now if you put baby guppies in the water, do

you think the tadpoles will eat the fish? Try to find out.

Living Things in Sea Water

There are many unusual animals that live in salt water, that could not live in a pond. Along the shore line, there are shellfish that are interesting to study. They are animals with soft bodies that are protected by hard coverings, or shells. These animals make their shells as they grow. The soft-bodied hermit crab is an exception. It does not make its own shell. It finds an abandoned snail shell and crawls into it. Do you know what a hermit crab is? Do you think these crabs are well named?





EXPLORE

Have you ever seen an oyster? Oysters are stationary. What does stationary mean? The shells of oysters are rough and bumpy, and they look like a rock. How do you think an oyster gets its food?

Try to open a clam or an oyster. Why are the shells so difficult to open? When you eat scallops,

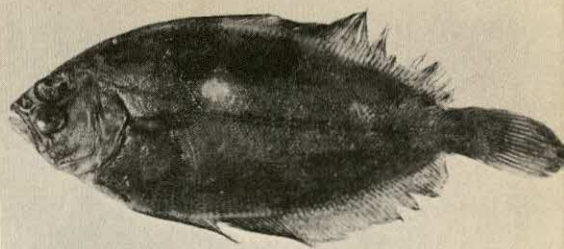
clams, or oysters, you are eating the strong muscles that hold together the two halves of the animal's shells. How do these muscles protect the shellfish?

By the seashore, you may also find starfish, and brightly colored sea urchins covered with prickly spines. Of what use are its spines to the sea urchin? □ □

The plants that are most common in the ocean are so small that they can be seen only with a microscope. These microscopic plants are algae. Free-floating algae and microscopic animals form plankton. Plankton is food for small animals like the oyster and large animals like the whale.

Some algae are anchored to rocks and sand, and grow into large plants. The kelps have stems as long as 100 feet. Air bladders on the stalks keep the kelps afloat in the water.

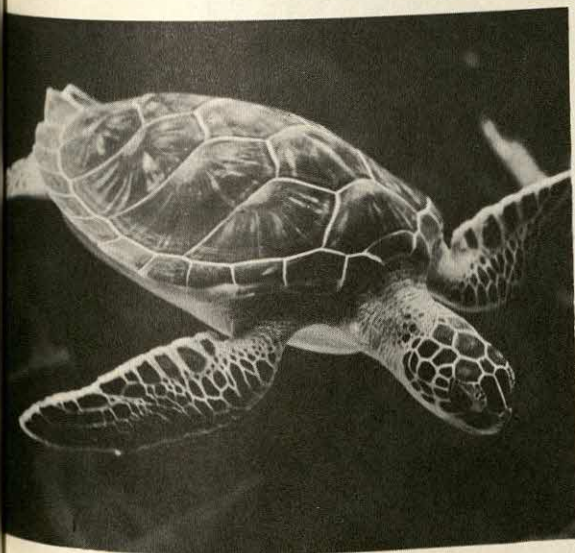
The turtle in the picture lives in the sea. You can tell a marine turtle by its legs, which are flattened like paddles. These turtles come out of the water and onto land to lay their eggs.



On the ocean floor are flat fish that are very specially suited to living in this habitat. The flounder in the picture is such a flat fish. The upper side of its body blends with the ocean floor. Why is this helpful to the flounder? It has both eyes on one side, the upper side of the fish. It swims in a strange way, on one side.

When the young flounder is hatched from the egg, it swims like any normal young fish, and its eyes are on opposite sides of its head. When it is about one inch long, one of its eyes begins to move. For example, the eye on the right side of the fish's head will move across to the left side, until both eyes are on the same side. This unusual movement takes only about three or four days.

How many other animals and plants do you know that are specially fitted for life in the ocean?





Seasonal Changes in Living Things

Noticing Changes in Spring

In places where the winter is cold, nature comes back to life in the springtime. Make a bulletin board display of the signs of spring. Describe the changes you see in the trees and bushes from day to day. What is happening as these changes are taking place?

Dogs and cats lose their heavy winter fur during the spring season. In the far north, weasels and snowshoe rabbits change their white winter coats for brown spring ones.

Birds leave their winter homes and fly north. Some song birds also change their colors. The male scarlet tanager changes from a dull yellowish green to a bright red. Some scientists think this makes the male bird more attractive to the female. After the male bird finds a mate, often he helps her to build a nest and to take care of the baby birds.

In the spring, fish and frogs become more active. Turtles and snakes begin looking for a suitable place to lay their eggs. Why do they lay their eggs at this time of year?

Moths, butterflies, and other insects appear again in spring. See how many different kinds of insects you can find.

What appears to be most important in bringing about the changes of spring? Explain how warm weather affects you.

Did you know that crickets are fairly good thermometers? Crickets chirp more rapidly as the weather gets warmer. When the weather gets very hot or fairly cold, they do not chirp at all.

INVESTIGATE

Get a large fish bowl or other container. Put about 2 inches of loose dirt in the bottom of the bowl. Put 10 or 15 adult crickets in the bowl. If you cannot find crickets, you can buy them at a store that sells fishing bait.

Provide pieces of apple and lettuce for the crickets to eat, and put some water in a small jar lid for them. Put a piece of sponge in the lid so that the crickets will not drown in the water. Cover the top of the bowl with a cloth. Tie a string around the mouth of the bowl to keep the cloth in place.



Put your cricket bowl in a tray of ice cubes. Wait several minutes until the cricket bowl cools. As the cricket bowl gets colder and colder, what do you notice happening?

Put the bowl near a radiator or heater. Do the crickets chirp when they get very warm? Get a thermometer and measure the temperature at which the crickets stop chirping. Cover the cricket cage with a dark cloth. Do the crickets chirp in the dark?

Hibernation

Some animals become inactive in very cold weather, others in very hot weather. The ground hog and the woodchuck are among the animals that sleep through the long cold winter. This resting in winter is called hibernation (*hy-ber-NAY-shun*).

A hibernating animal is in a deep sleep. Its heart beats very slowly. It breathes very little. Its body temperature is lowered.

Many frogs, too, sleep through

the cold winter. If you can get a frog, you can cause it to become sluggish by lowering its body temperature.

OBSERVE

Put the frog in a jar with air holes punched in the lid. Add a small amount of water to the jar to keep the frog's skin moist.

Place the jar in the refrigerator (not the freezer!) overnight. When you remove the jar from the refrigerator, notice the frog's movements. How long is it before the frog begins to move at all? Put the frog on its back. Touch him gently. Is the frog able to get up? How long is it before the frog becomes active? ☐ ☐

The bear's winter sleep is somewhat different from hiberna-

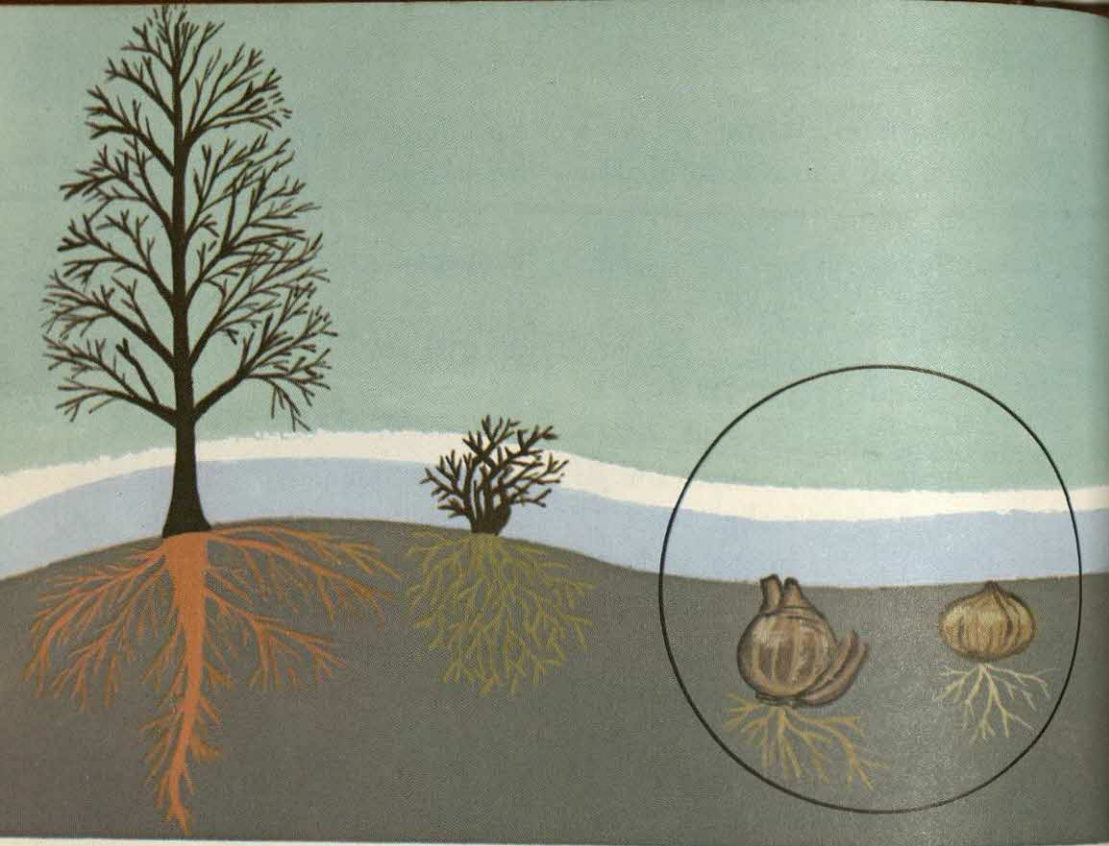
tion. The bear's heartbeat and breathing slow down, but its body temperature remains high. The bear may wake up in mid-winter, if the weather is mild, and then go back to sleep again till spring.

Estivation

Some animals will pass the summer in a sleepy state. This state is called estivation (*ess-tuh-vay-shun*). Some snails and frogs become inactive or estivate when the weather is hot and dry. Some reptiles estivate.

The ground squirrel of Southern California both estivates and hibernates. This little animal may begin resting in July and sometimes remains this way until the following spring. How might this long rest benefit the squirrel?





Dormancy

Plants, too, go through periods of inactivity. Some appear to be dead during the winter. We call the plant's inactive period a time of dormancy.

INVESTIGATE

Many plants shoot up in the springtime. Where are they during the winter? Do all of them come from seed? What parts remain in the soil during winter?

You can show that there are seeds, roots, and stems in the soil ready to come to life when the weather gets warmer and the soil

gets enough moisture. Dig up some rich soil from under dead leaves, and put it in a flower pot. Remove any green plants that are already growing in the soil. Water the dirt in the flower pot. After a week or so, look to see if you have any plants growing in the pot. Where did they come from?

Take a twig from a flowering tree or bush which has not yet bloomed and keep it in water in your room. What happens? If the same twig had been cut last fall and put in water, it would not have bloomed. □ □

We know that man too must sleep. Usually he sleeps part of every day. Is his sleep like that of the plant?

Do you think man's temperature drops when he sleeps as does that of a hibernating woodchuck? Do you think his heartbeat slows down? Would his digestion almost stop, the way a woodchuck's does?

Man does not hibernate, but scientists are hoping that he may in the future. Already, doctors can slow down a man's heartbeat and his breathing by cooling his body. They do this in order to make brain and heart operations less dangerous to the patient. Perhaps, if man can be made to hibernate, he could travel into space with

less food, water, and air than he would need if he were awake and moving around. It will take many years for man to reach some of the other planets. If he could hibernate on the way, it would not be such a tiresome journey.

Migration

In spring, many birds move from one part of the country to another and even from one country to another. Cliff swallows, redstarts, and grosbeaks fly north from Mexico and Central and South America to nest in the United States and Canada. The ruby-throated hummingbird flies across the Gulf of Mexico from Central America back to the east-





ern part of the United States to nest. The whippoorwills that spend their winter in the southern tip of Florida return to raise their families in New England. How many miles do they fly? Would you like to take such a long trip each year?

Some people also spend their winters in Florida. Why? Why do

you think the birds make these long trips? When animals move in large numbers from one place to another, they are said to migrate (MY-grayt).

The reason birds leave their summer homes and fly hundreds or thousands of miles to another place is not fully understood by man. When the bird leaves the

north, there is still plenty of food for it, and the weather has not yet turned cold. We say the bird migrates at a certain time because of a sense which we call instinct.

In order to find out about the migration of birds, scientists trap them and put bands on their legs. Each band has a number to identify the bird. There are also instructions on the band for anyone who captures this bird or finds it dead. Anyone who finds such a bird is asked to write to the Bureau of Biological Survey, telling the bird's number and the name of the place where it was found. By such means, scientists have found out about the routes of birds when they migrate.

IDENTIFY

What birds were around your home all winter? These birds are called winter residents. What birds return for the spring and summer? These are called summer residents. Other birds will stop for only a short time on their return trip to their nesting grounds in the north and are called migrants.

Make a list of the birds that are summer residents and those



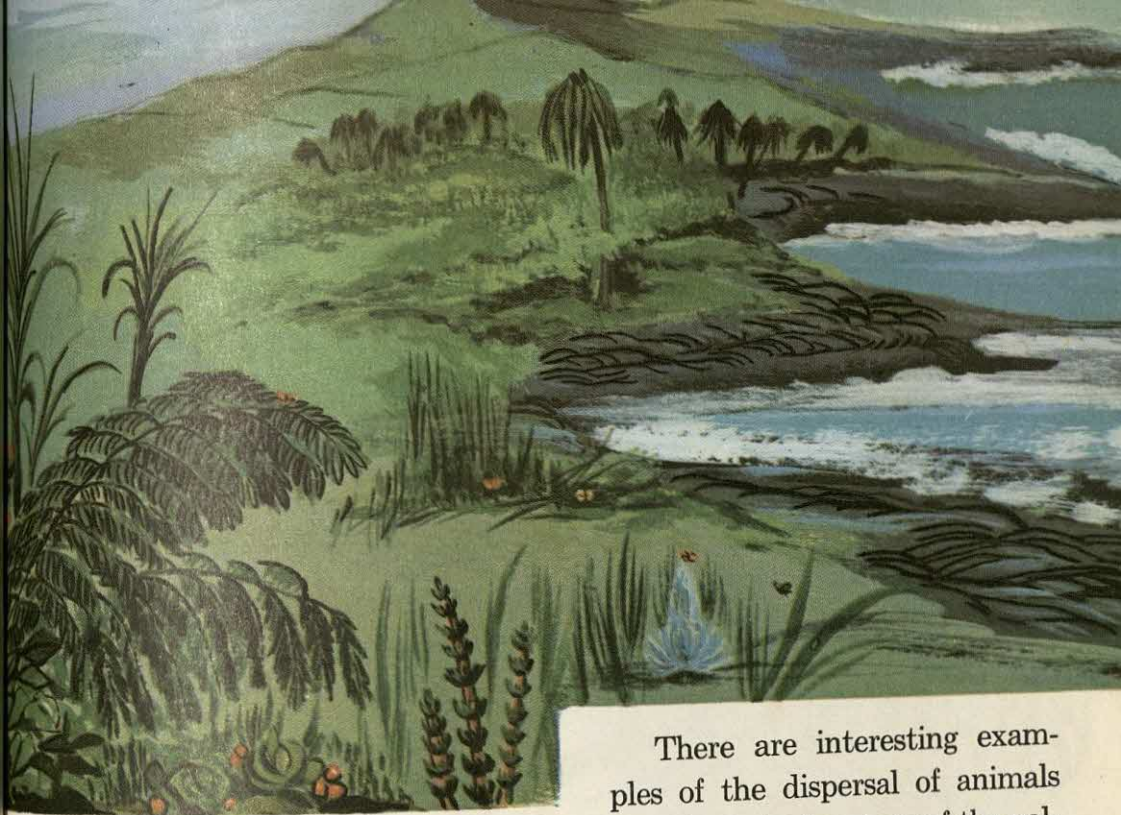
that are winter residents where you live. Do you think that birds that eat insects will stay near your home during the winter? Why? What do the birds eat during the winter? Why are there different birds in the woods than in your yard at home? Draw pictures or take photographs of the birds around your home. Make a bulletin board display. □ □

Other animals besides birds migrate. We cannot really explain migration. One theory is that birds know it is time to migrate when the days begin to get shorter in the northern regions. It is even more difficult to explain the migration of some fish, such as the salmon.

Salmon spend years out in the ocean feeding and growing. When they are full-grown, they are ready to return to the fresh waters where they were hatched. At certain seasons of the year, large numbers of salmon swim up the rivers against swift currents. They may leap waterfalls as high as 12 feet in their journey upstream. Did you know a fish could jump? Measure 12 feet and see if you can jump as high as a salmon.

If the salmon make the dangerous journey successfully, the female lays her eggs and the male covers them over with a whitish fluid from his body called milt. We say the fish have spawned. Someday we may find out why it





is better for salmon eggs to be laid in fresh water. This will tell us why the fish need to make such a difficult journey to return to the place where they were hatched.

Accidental Migration or Dispersal

Some migrations are not so regular as those of the birds and fish just described. Sometimes animals may migrate to another land on boats or airplanes, or they may be carried by wind or water. These kinds of migration we call dispersal (dis-PER-sal).

There are interesting examples of the dispersal of animals and plants in the story of the volcanic island of Krakatoa. When the volcano erupted in 1883, it destroyed most of the island. On the portion of the island that remained, all living things were killed by the hot ashes from the volcano.

Thirteen years later, the island was fairly well covered with green plants. Grasses, ferns, wild sugar cane, orchids, and horsetail plants were seen by scientists who visited the island. Young coconut trees grew on the shores. Flies, beetles, butterflies, and moths flew among the plants.



By 1928, many other small animals had joined the insects. Lizards and even one kind of crocodile and one kind of snake were found on the island. How might each of these animals have arrived at Krakatoa? Do you think the lizard and rat could have floated on driftwood? How did the coconut trees get there?

ACTIVITY

You can do an activity to show such dispersal of animals and plants. Put some soil in a pan. Heat the soil in an oven at 400° F for 1 hour, to kill the animal and

plant life in it. Put your pan of dirt outdoors. Keep the soil moist. How long is it before you have some plants growing in your soil? How long is it before you find insects or other animals on the soil or in it? How did they get there? □ □

A collection of seeds is another interesting way to study the dispersal of plants. The milkweed seed has little silky hairs growing out of the seed covering. These little hairs are like parachutes that help the seed to travel. Cat-tails, which grow along the banks of ponds and streams, also have

“flyaway” seeds, but their seeds are packed together very closely. Sometimes these seeds are loosened by birds. Have you seen other seeds that fly?

The seeds of some flowers are found in holders called pods. When the pod ripens it opens and the seeds pop out, sometimes making a loud noise. One such noisemaker is the sandbox tree which grows in South America. This tree has been called the “monkey’s dinner bell.” Can you guess why?

Many seeds are contained in fruits that help in the dispersal of the seed. For example, a bird will pick a cherry, carry it for some distance, eat the soft part, and then drop the seed. Do cherry trees benefit from the fact that birds like cherries?

Other animals also carry seeds. How might the seeds in the middle picture be carried by animals and men?

Coconuts are the fruits of the coconut palm tree. They contain the seeds from which new trees can grow. Often, the ocean carries coconuts hundreds of miles from one island to another. How does the covering protect the seed?





Living Things Are Protected in Their Surroundings

Form and Structure

The ability to move quickly is the best means of protection for many animals. Many birds have no other means of defense. Both the cottontail rabbit in the eastern part of this country and the jack rabbit of the western prairies hop fast enough to give a dog or fox a merry chase. Some mammals swim to escape from their enemies. Do you know of any

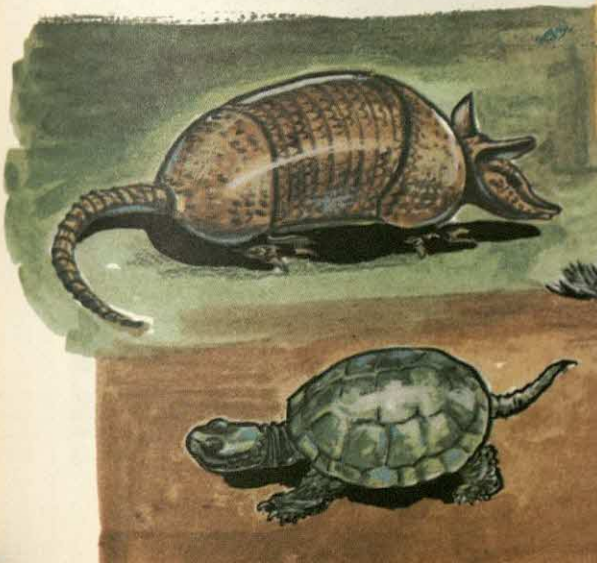
mammals that can fly? Have you ever tried to catch a frog on the side of a pond? What happened? How does a fish get away from danger?

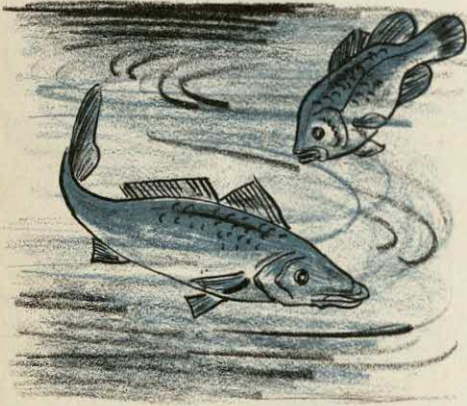
Some flies in the air beat their wings as many as 200 times a second. This is very fast movement. See how many times a second you can tap your finger on the table. Can you tap as fast as the fly can move its wings?

How do horses, tigers, and crayfish protect themselves? Of what use is its "sword" to the swordfish?

Many animals are protected by their outer coverings. Shells of armadillos, turtles, oysters, and clams, the quills of porcupines and hedgehogs, and the hard coverings of beetles help these animals to protect themselves.

Plants, too, are protectively covered. Trees have a tough covering of bark. The pineapple has an outer covering that looks much like armor, which protects the juicy fruit underneath. Spines help to protect the cactus from being eaten by thirsty animals on the desert. Thorns keep animals from eating raspberry, blackberry, and even rose bushes. Can you think of other ways in which plants are protected?





Protective Coloration

The colors of many animals help to conceal them from their enemies. The white coat of the polar bear makes the animal difficult to see against the white snow on which it spends so much of its time. Fish that live near the surface of the water, and especially those that swim in the open sea, are steel-blue on the back. How does this coloring help to protect the fish? Is it easy to see a frog near a pond? Why?

Many insects are well disguised from their enemies by color. A grasshopper may be as green as the leaves and grass it feeds on. The walking stick, a twig-shaped insect, is green in the spring when it is feeding on the young green leaves. In autumn, when the leaves fall, the walking stick's color changes to a rusty brown. Among the green spring leaves or the brown autumn leaves, the walking stick is well hidden from other animals.

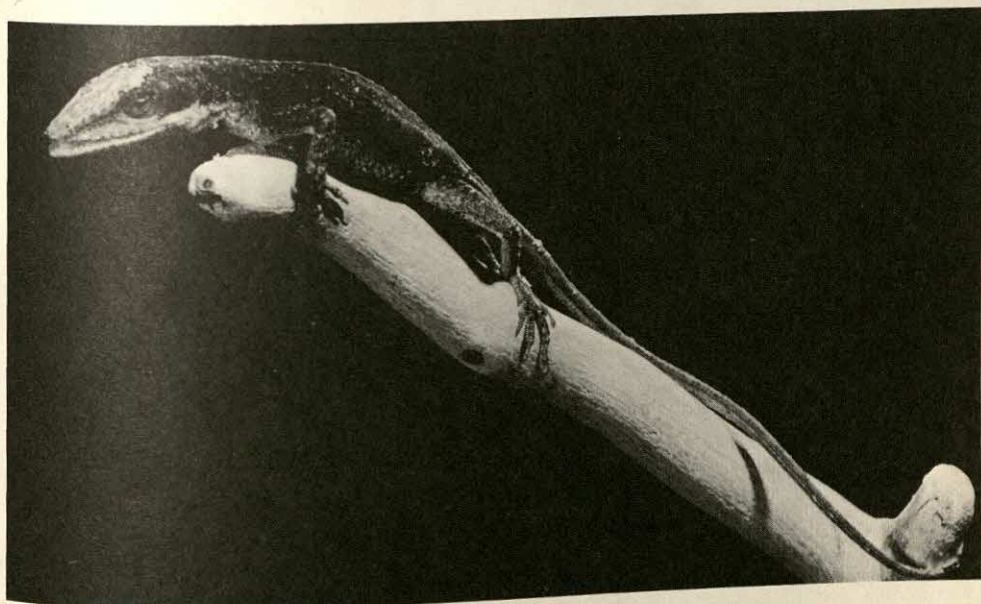
DISCOVER

If you can catch a walking stick, put it in a jar with twigs and leaves. Punch a few holes in the top of the jar to provide air. Bring the jar to class. At first, your classmates may think you have only a jar of twigs and leaves. They may not find it easy to discover the walking stick.

Some animals can change color according to the seasons, but others can change color in a matter of minutes. A flounder resting on a sandy ocean bottom will be evenly colored. If it swims to a place where there are stones and pebbles, the flounder will take on a speckled appearance that blends with the surroundings.

The American chameleon is famous for its ability to change color. Placed on a dark background, this little lizard will become brown. On a green leafy branch, the American chameleon will take on a green color. The change in color is not a very sudden one. Each time, it requires several minutes.

Take a walk around the school grounds or in a vacant lot near home. How many examples can you find of animals that are protectively colored? Make a list of them. Add to it when you find others. Perhaps your list, added to those of other members of the class, could be made into a bulletin board display.



chameleon



Warning Coloration

Hornets, and many other insects that have a sting, are yellow and black. Do you catch yellow and black insects in your bare hands? Why?

The Fire-bellied toad of Europe produces certain substances from its skin which give it a bad taste. This toad has a bright red belly and black markings on its legs. If a stork or other bird swoops down to catch such a toad, the toad flops over on its back. The bright color is a sign to the stork that this is a bad-tasting toad, so the stork flies off.

The stripes on the back of the skunk are thought to be a fair warning of the presence of this animal which can spray its enemies with such a bad-smelling liquid. Can you recognize a skunk?



Protective Habits

Animals are also protected by their habits. The American beavers cut down trees with their sharp teeth and build dams in ponds or streams. They use mud, sticks, and stones to dam up part of a stream or river to form a pond. Within the pond they build their home. Their dams may be 12 feet in height and as long as 200 feet. Sometimes the dams change the direction of water and cause flooding of the surrounding land. Beaver dams are so well built that they may last for years.

Some animals "play possum" or appear to be dead when faced with danger. In our country, the first animal which was noted to pretend to be dead or injured was the opossum. That is why we call this act "playing possum."



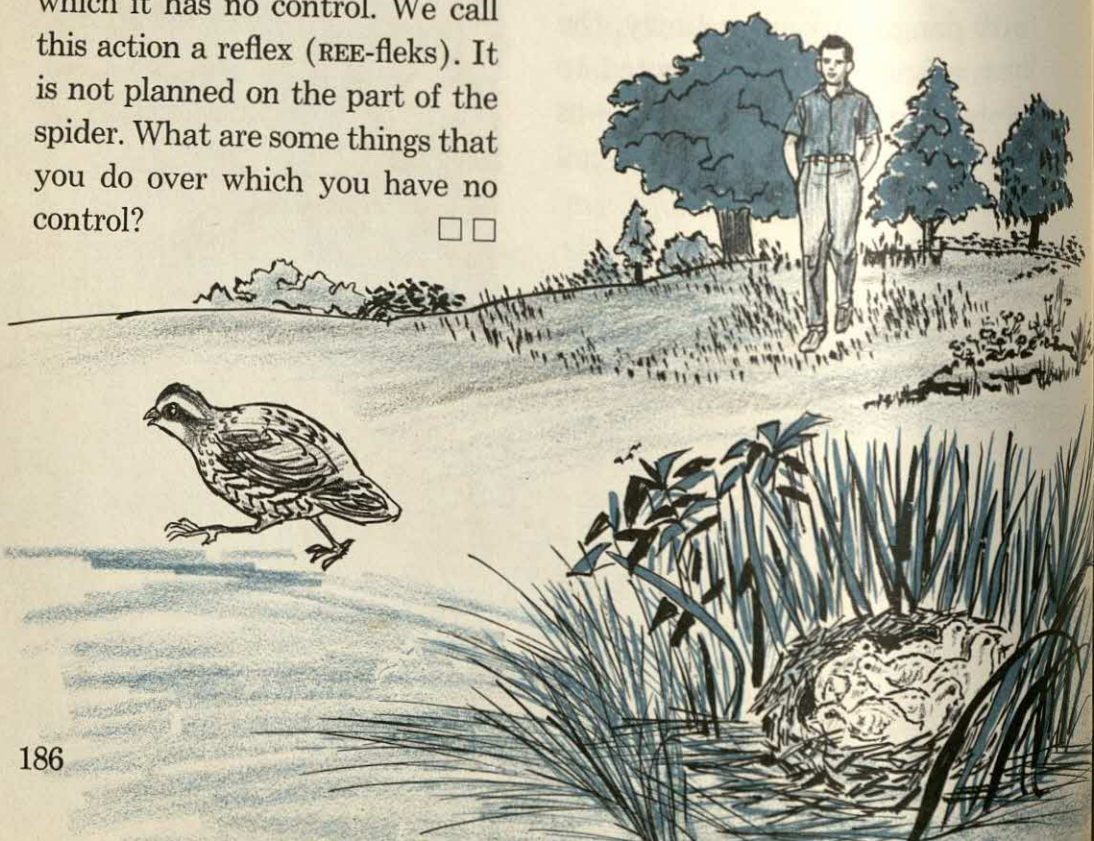


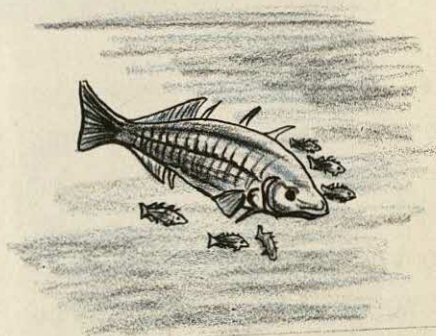
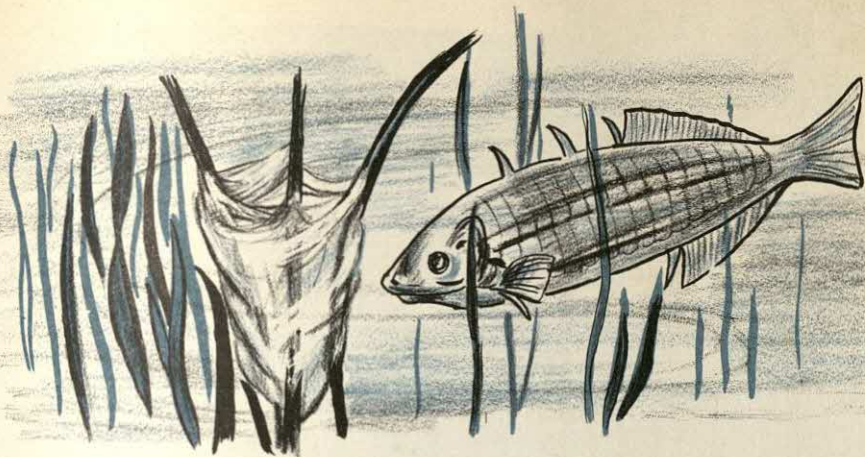
EXPLORE

Try touching a spider with the tip of a pencil. Some spiders will run away. Others will drop to the ground stiffly, as if pretending to be dead. Actually it is an action that the spider performs over which it has no control. We call this action a reflex (REE-fleks). It is not planned on the part of the spider. What are some things that you do over which you have no control? □ □

Some young birds, like the bobwhite, stay very still when their mother gives the signal that danger is near. This action is called "freezing." The baby birds remain "frozen" until the mother bobwhite gives them the signal that all is clear.

When you go out in a field, you may be able to cause mother birds to fly away from their nests. This is called flushing the bird. But you will not find the nest at the spot from which the mother bird flew. Why do you think she will run some distance from the nest before she flies up?



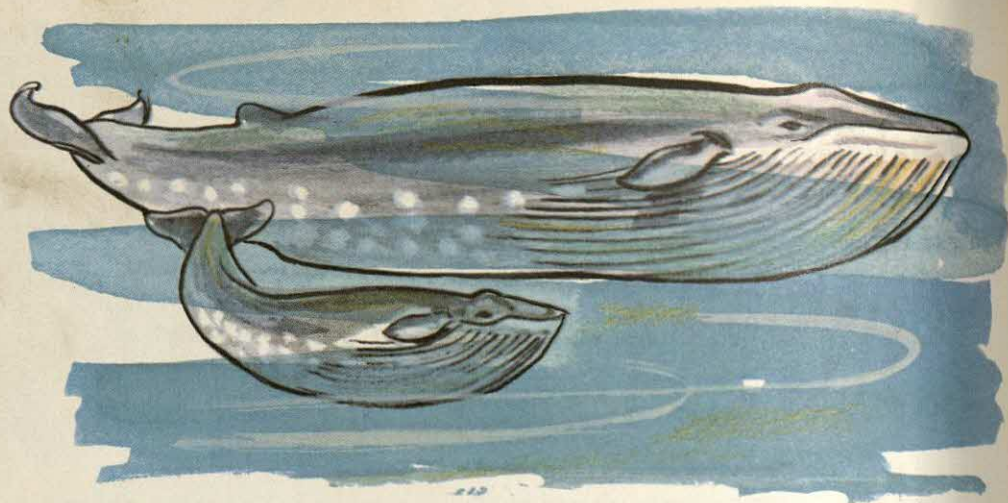


Animals Protect Their Young

Since most fish and other water animals do not spend much time caring for their young, they lay great numbers of eggs. An oyster may lay many millions of eggs in one season. Most of the eggs and many of the young oysters hatched from the remaining eggs will be eaten by fish.

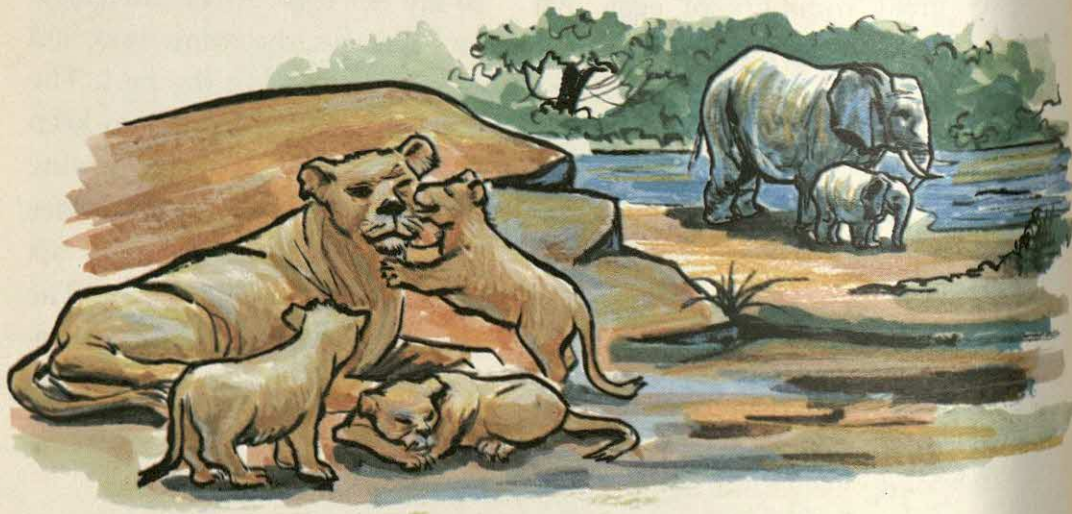
There are a few exceptions to the general rule that water animals do not care for their eggs and young. The male stickleback fish seems to plan carefully for the young fish. First he builds an

underwater nest such as you see in the picture. He works all alone. Only when he has finished does he bring in a female stickleback to lay her eggs. After the female lays the eggs, she swims away and does not return to the nest. The male fish moves his tail to keep a stream of fresh water flowing over the eggs. This water provides oxygen for the eggs. After six days the eggs will hatch. The father keeps the little ones together and protects them until they are big enough to go off by themselves.



Whales and porpoises also take good care of their young. They do not lay eggs, but give birth to live baby whales and porpoises. A baby blue whale is 25 feet long when it is born. The young whale gains about 200 pounds a day. Until it is six or seven months old, its food is the milk of the mother whale. During this time the mother whale protects her baby from other animals.

Lion cubs and bear cubs are protected and trained by their mothers for almost two years. Baby elephants stay close by their mothers for over five years. Which is the most helpless baby that comes into the world? How many years does it take before a child can get along without parents? What would happen to you if you had to take care of yourself without your mother and father?



Animals and Plants Store Food

The squirrel busily tucks nuts away in a hollow oak tree for his meals in the coming months. Gnawing mammals and man store up food for the winter. Beavers store pieces of bark and wood in the bottom of a pond so that they will have food even when the pond's surface and the things above ground are frozen. Squirrels, chipmunks, and beavers are busy in autumn storing food and preparing for winter.

In the storehouse of one chipmunk burrow was found a half pint of wheat, a quart of hazelnuts, two quarts of buckwheat, and a few dozen acorns. Squirrels dig holes in the ground for the nuts which they eat during the winter. Some forget where they stored their nuts. Is this good for the trees?

Plants also store food for future use. Some store it in their roots, as do beets and carrots. The white potato is an underground stem in which the potato plant has stored food that it can use to begin growth the next spring. Can you name any other plants or parts of plants in which food is stored? Do seeds have food stored



in them? Why do seeds need stored food?

OBSERVE

Place a sweet potato in a glass or vase, with water covering most of the potato. Watch it for several days. What happens? What part of the plant is the sweet potato? How can you tell?



Changed Surroundings Affect Living Things

From a study of bones found in the earth, we know that there were huge reptiles called dinosaurs living on the earth many millions of years ago. None of them is alive today.

We do not know all the reasons why the dinosaurs died out,

but changing weather may have been one of the reasons. Perhaps the weather became too hot for the dinosaurs. Perhaps, as the great ice sheets covered parts of the earth, it became too cold for them to get enough food. Whatever the reason, we know from our observations today, that weather has a very great effect on the lives of animals.

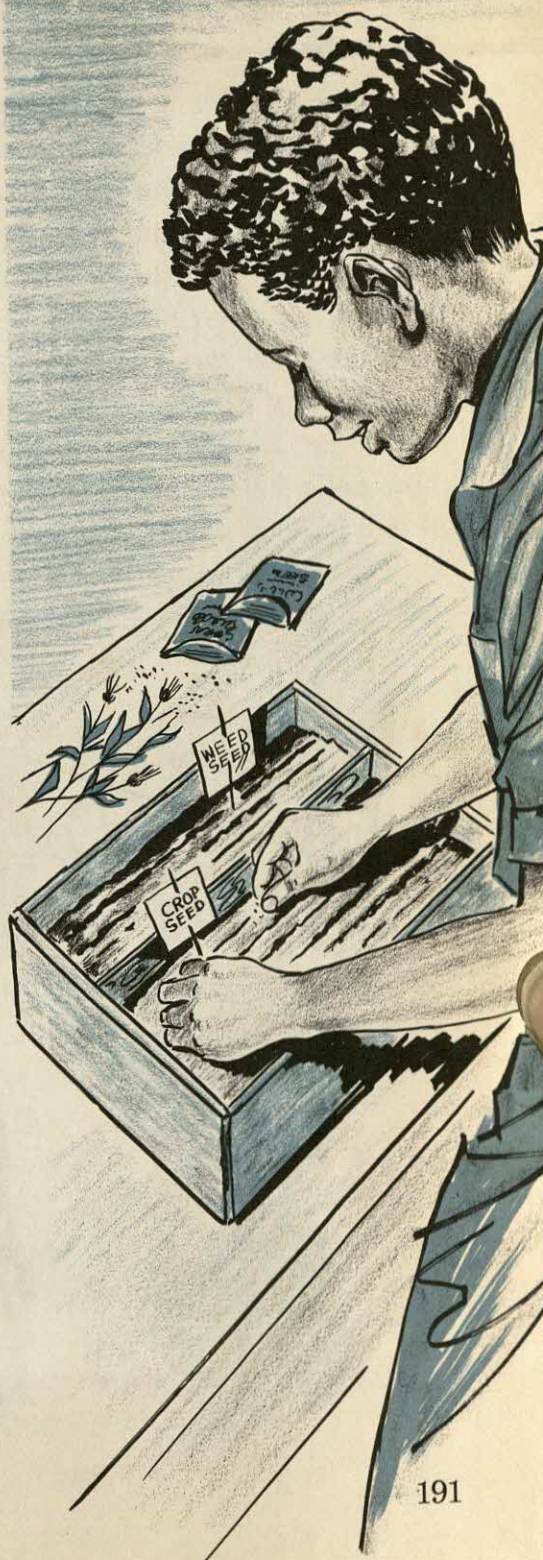
Every year, many animals die that cannot adapt to changing weather. If the hibernating turtle does not dig below the frostline to make its winter home, it will freeze during the winter. If the land gets too dry, toads in hibernation will die. Floods and high waters bring rabbits and rattlesnakes out of their burrows. What do you think happens to those that do not get out of burrows? What happens to seeds that do not get enough moisture and soil?

Some plants may prevent the growth of others. Plant the same number of weed seeds and crop seeds in a pot or a box. Which seeds grow faster? Why do farmers have to get rid of weeds?

REPORT

Have you set up a terrarium in your classroom or at home? If you have, make a report on the animals and plants in it. Have any of the animals or plants died? Why? Did you have food and oxygen for your animals? Did you have enough light and water for the plants? □ □

Plants and animals will die if they do not have the surroundings to which they are suited.



Plants, Animals, and Man

Food Chains

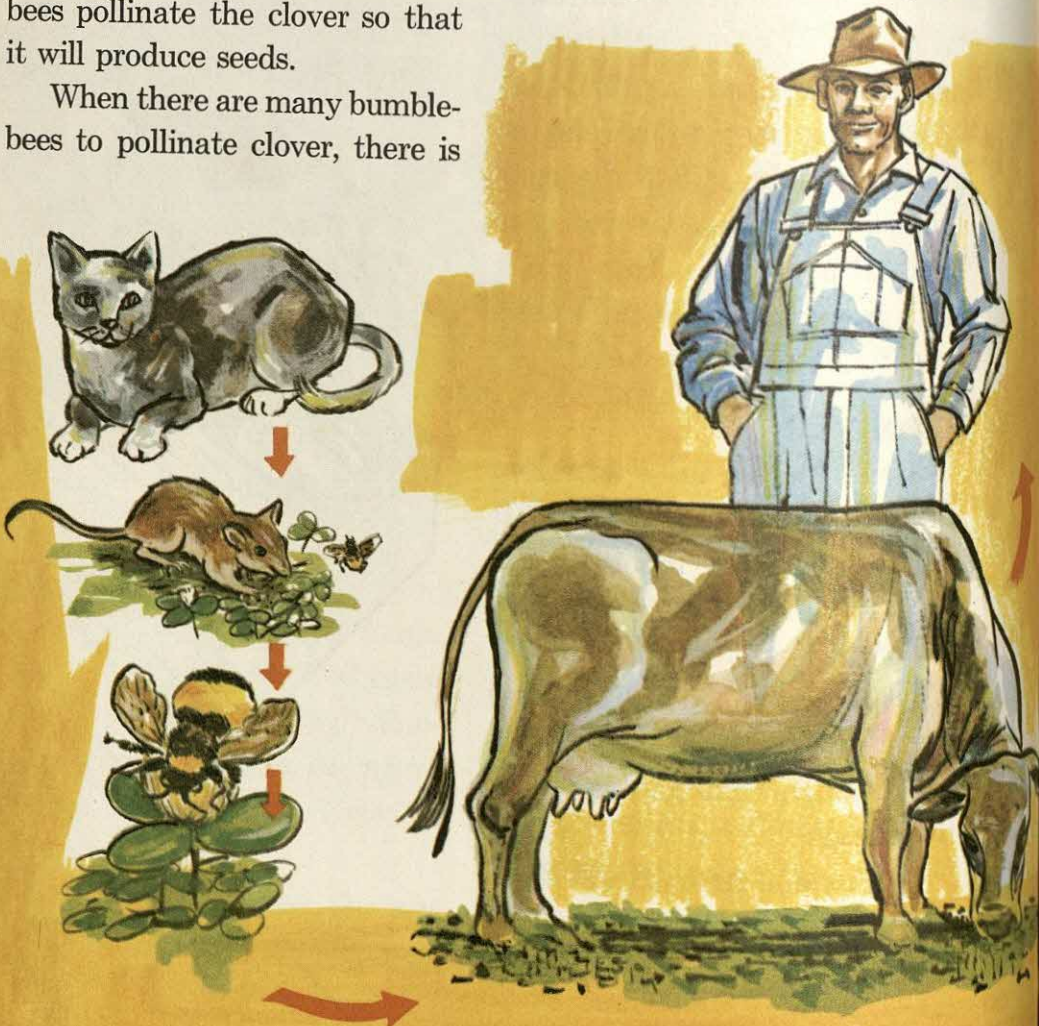
Charles Darwin, a famous English scientist, once said that the amount of clover seed produced in a season depends on the number of cats in the neighborhood of the clover fields.

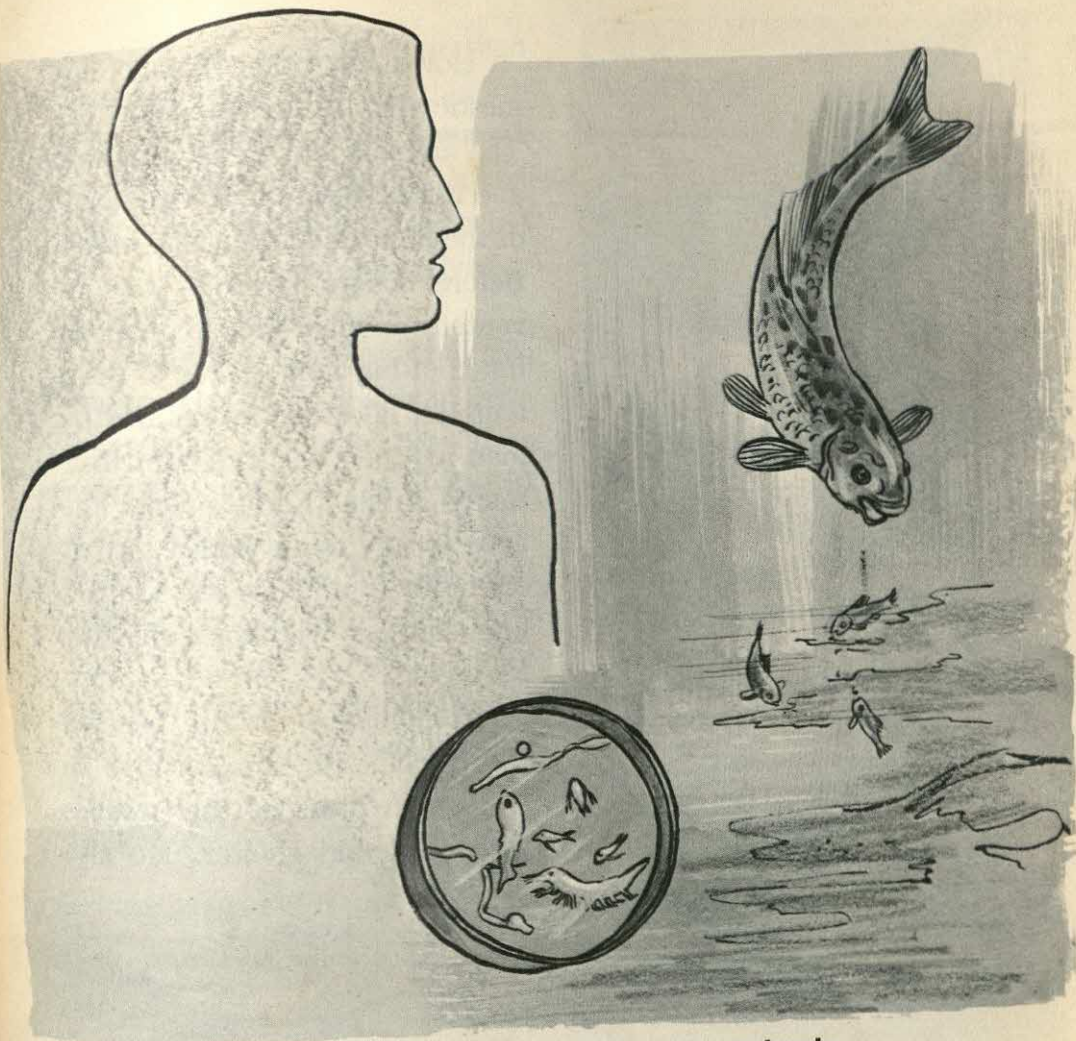
This is the way Darwin reasoned. Cats eat the field mice which eat bumblebees. Bumblebees pollinate the clover so that it will produce seeds.

When there are many bumblebees to pollinate clover, there is

plenty of clover seed, and a large crop of clover in the next season. Farmers fatten cattle on clover hay.

How would the beef supply be affected by an increase in clover hay? How does increased production of beef affect the cost of beef on the market? How is man affected by increased clover yield?





Man is the end of many of the food chains. Man eats the big fish which eat little fish. Little fish eat tiny water animals which eat algae. Where do the algae get their food?

We call these relationships of animals and plants food chains or food webs. Think of another food chain. How far back can you follow it?

Domestic Animals

Hundreds of thousands of years ago all animals were wild. They roamed over the earth in search of food and water. In time man began to tame animals. The first animal to be tamed was probably the dog. At first dogs may have been only companions. Then man found that these animals could help to protect him.

How many other kinds of domestic animals can you think of? The animals that man has tamed and raised supply him with many of the important things he needs. Before modern machines were invented, animals helped man do much of his work. Some of these animals, however, are valued by man for their beauty or for their funny habits. For example, the ancient Egyptians tamed the cat originally as a house pet. Do you know anyone who has a monkey for a pet?

In exchange for the benefits which domestic animals give to man, man provides the animals with food and shelter. He also



protects his animals from their enemies and cares for them if they become sick. Most domestic animals have lived with man for such a long time that they could not take care of themselves if allowed to run wild.

Even though domestic animals are so useful and valuable to man, you should remember that they are only a small number of the different kinds of animals in the world. Can you think of any wild animals that are highly valued by man? Are minks or foxes that are raised on ranches really tame? Do you think a ranch fox or mink would be able to survive in the wilderness?





settlers carelessly started fires that destroyed great amounts of forest and grassland.

Each time that man moved into a new area, many wild animals were displaced from their natural habitats. Many others were carelessly killed. For example, the American buffalo once roamed the plains in herds of many thousands. But, by the 1880's, their total number was reduced to about 550. These animals were often killed a thousand at a time, merely for the sport of the hunters.

Another North American animal that once flourished in great

Conservation

When settlers first arrived in North America, the land was rich with forests, wild animals, fertile soil, and other natural resources. These natural resources seemed so vast that the pioneer believed that they could never be used up. He cut down the forests to clear farmland, and he shot the wild animals for food. He often used the soil unwisely, and, in time, it became exhausted. Sometimes the



numbers is the passenger pigeon. In 1813, John James Audubon, the famous naturalist, reported having seen a flock of passenger pigeons so huge that it took three days for them to pass by. Today not one passenger pigeon is alive. Hunters wiped them all out.

By the late 1800's many people realized that the nation's resources were being used up as a result of man's carelessness and greed. These people wanted to stop the wasteful use of our resources. They began the conservation movement in order to protect our wildlife, forest lands, and other resources.



President Theodore Roosevelt was a powerful supporter of the conservation movement. During his administration, 1901-1909, he helped to make the idea of conservation popular. National parks were created, hunting and fishing laws were passed, and many forest lands were put under government control. What wild animals live in your area? Can they be hunted? What are the legal seasons for hunting and fishing?

Man Changes His Surroundings

Animals and plants live in every imaginable sort of habitat, from the hottest to the coldest, from the wettest to the driest. But it is not the same plants and animals that live and thrive in these different climates. A water lily would have as little chance of survival in the desert as a fish out of water. Each animal and plant lives in the place to which it is best suited.

Man is very different from all other animals. He alone can live anywhere on the earth, for man can change his surroundings to suit him. Man cannot live without air to breathe, but he does not have to stay where the air is naturally present. He can take his atmosphere with him and travel under the sea or out into space.

Man makes clothing and builds houses to protect him from the weather. He provides a comfortable climate in his house by heating or air-conditioning it. He drains swamps to make dry land and he irrigates the desert.

In changing his surroundings to suit him, man must be careful not to destroy the land or to harm the animals that live on it. This is his responsibility: to use the world of nature carefully and well, so that it can be used and enjoyed by people in the future. The more each man learns about plants and animals, and about the ways they depend on each other, the better he will be able to meet his responsibility.

What have you learned about living things and their surroundings? What kinds of living things

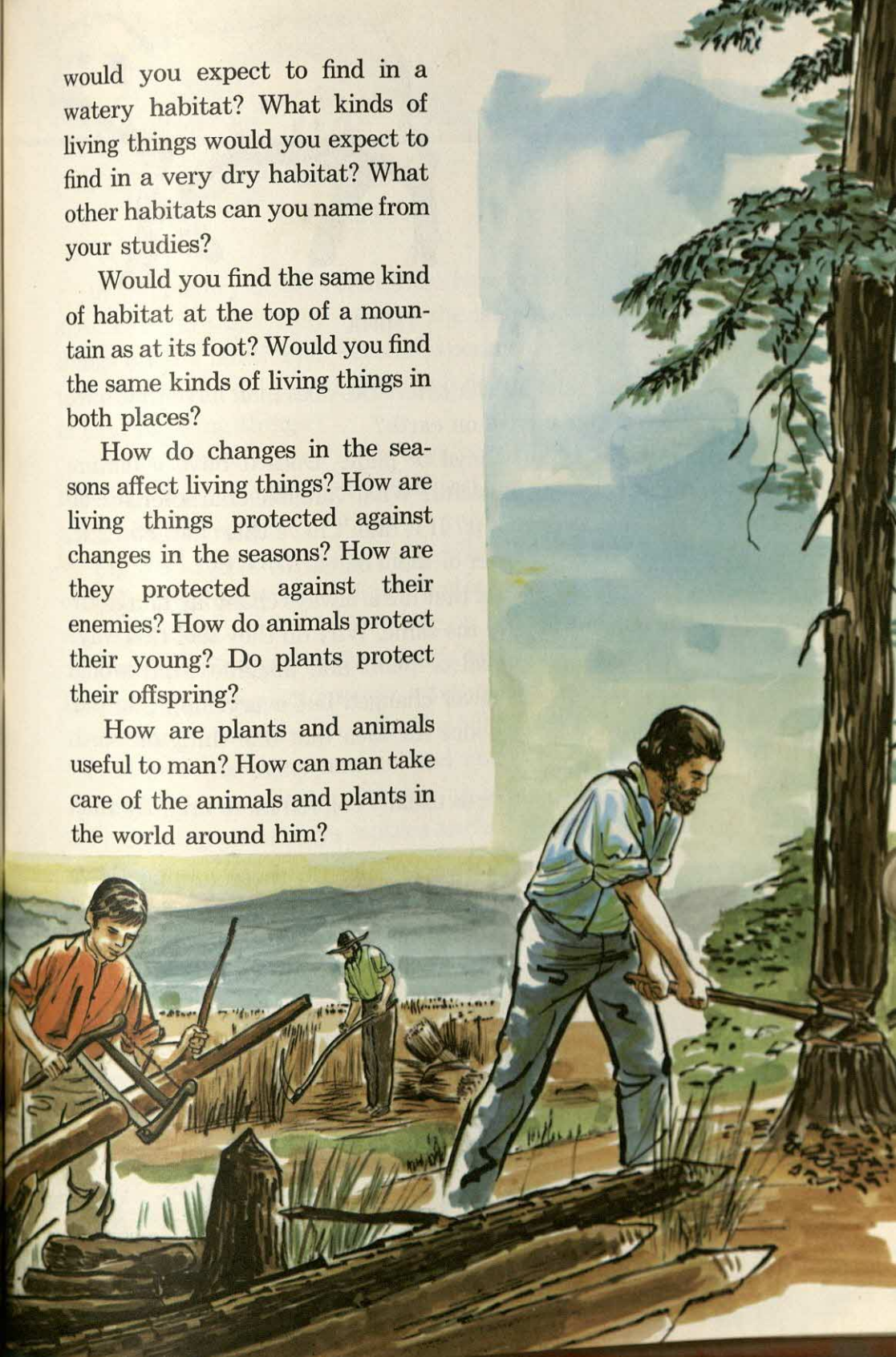


would you expect to find in a watery habitat? What kinds of living things would you expect to find in a very dry habitat? What other habitats can you name from your studies?

Would you find the same kind of habitat at the top of a mountain as at its foot? Would you find the same kinds of living things in both places?

How do changes in the seasons affect living things? How are living things protected against changes in the seasons? How are they protected against their enemies? How do animals protect their young? Do plants protect their offspring?

How are plants and animals useful to man? How can man take care of the animals and plants in the world around him?





THINK

What valuable characteristics does man have that have helped him survive on earth?

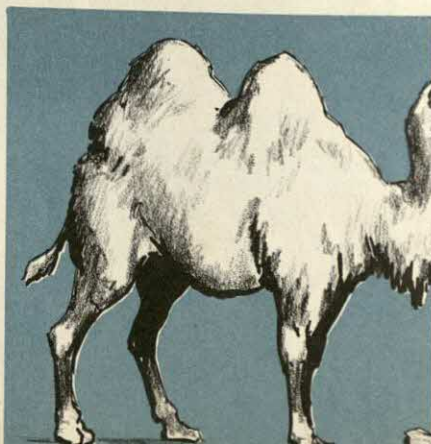
Think of an animal or plant. Does it have a feature that is pleasing or useful? What valuable characteristic do you like best about it? If it didn't have this characteristic, would there be fewer of them on earth? Why?

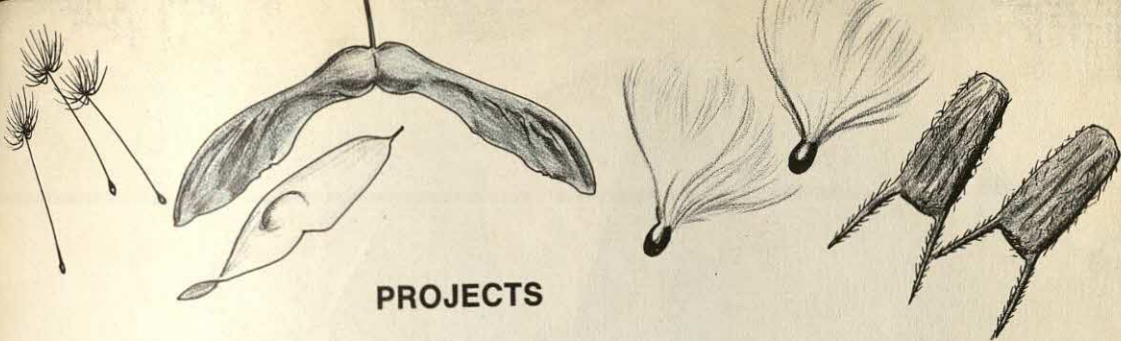
Many people feel that life is always changing and nothing remains exactly the same. Why do they feel this way?

Select one animal or plant and imagine what would happen to it if it never changed but everything else did. Make up a story about the idea that one thing on earth never changed.

Why are male birds usually colored more brightly than female birds?

What unusual characteristics do these animals have that have helped them adapt to their surroundings: the elephant, the giraffe, the camel, the gorilla, the hummingbird?





PROJECTS

In the history of the earth there have been several ice ages. Do you think they affected the land and the living things on the land? Plan several experiments that would test what very cold conditions would do to different kinds of land or living things.

Find out how various seeds have been adapted so that they can travel from place to place. Collect and display some of these seeds.

From a local butcher shop, obtain hearts, lungs, brains, eyeballs from different animals and compare their sizes and structures.

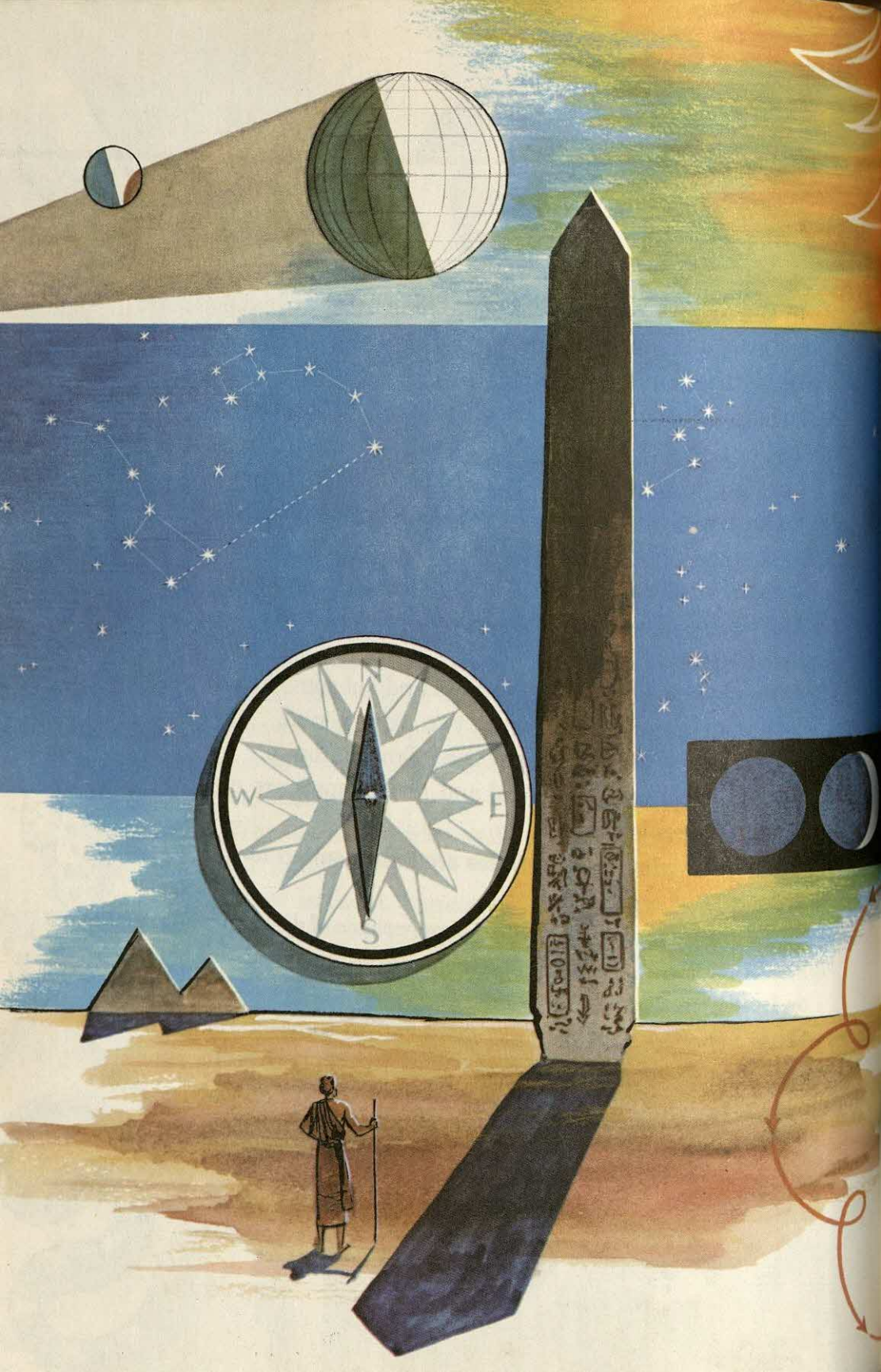
Obtain some fresh water planaria and cut some in half. Record your observations over a two week period.

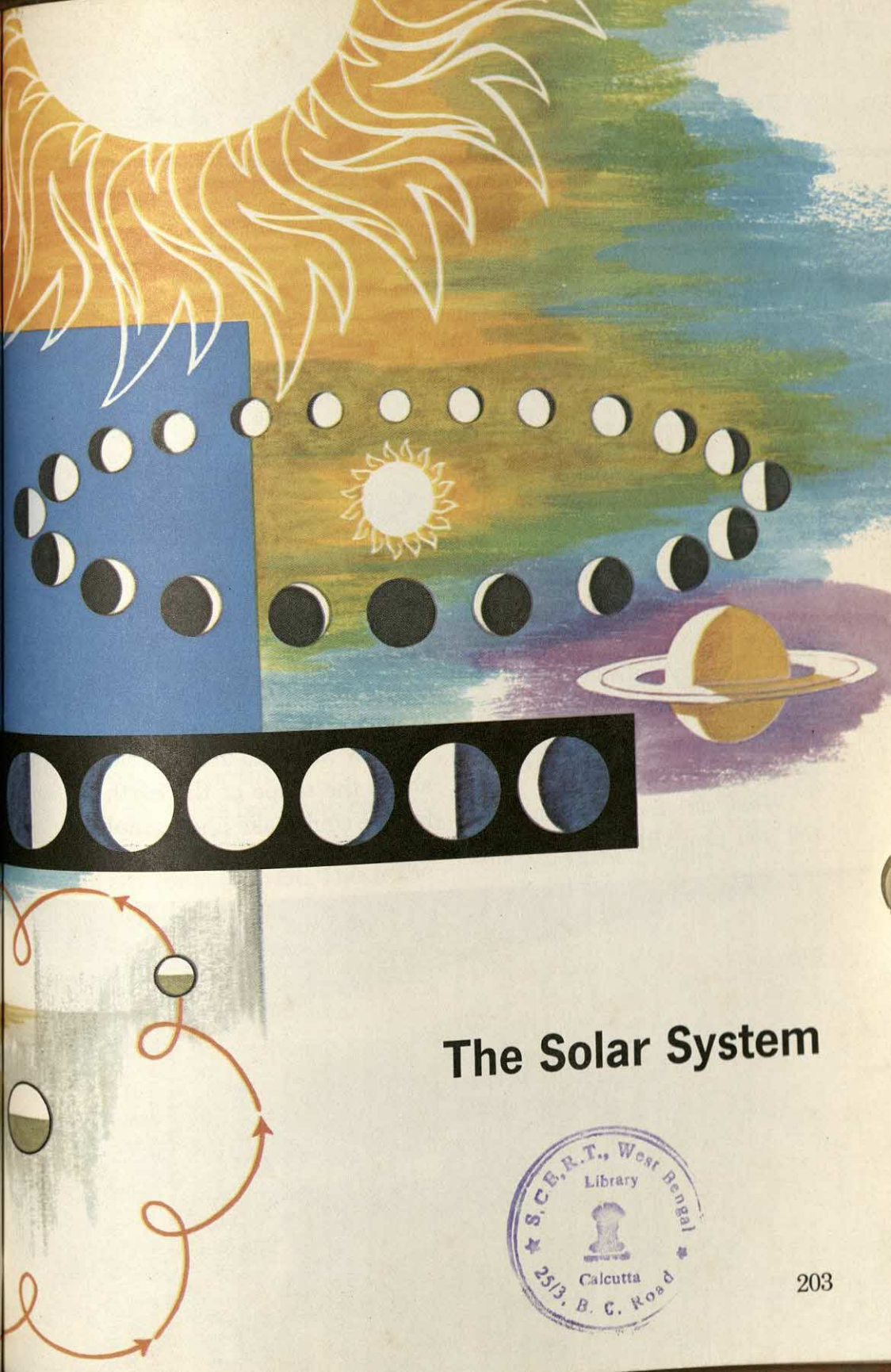
Do some research on one of the following topics:

1. Find out why many unusual and rare animals are now found only on islands.
2. Find out in what ways reptiles are better suited for life on land than amphibians.
3. Find out some reasons for the disappearance of dinosaurs.
4. Find out the differences between reptile eggs and fish or frog eggs. Explain the differences.

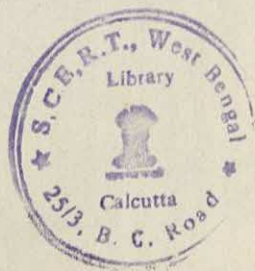
It is believed that bees are attracted to some flowers partly because of their beautiful colors. But do bees really see colors as we do? Make up an experiment to find out.







The Solar System





What is the shape of the earth?
How do you know?

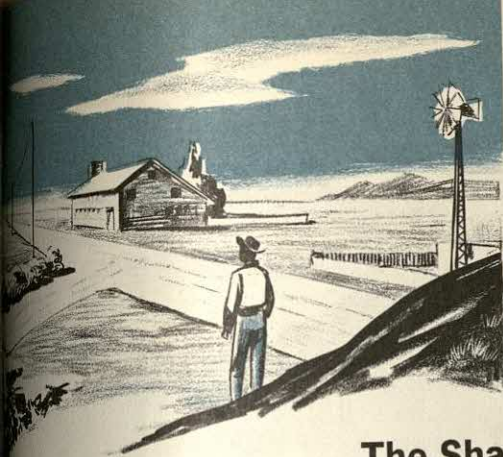
The photographs on this page were taken by Astronaut L. Gordon Cooper. His capsule, Faith 7, was orbiting 100 miles above the surface of the earth.

What can these photographs tell you about the shape of the

earth? Do both photographs show the same part of the earth's surface? How do you know? What is the same about both photographs? What is different?

How was man able to find out about the shape of the earth before he could take photographs of it from near space?





The Shape of the Earth

Look at the Earth

Choose a place that will give you an open view of the earth. Depending where you live, this place may be a wide street, a large park, an open meadow, an airport, or the shore of a large body of water. Look around you. If this view were all you knew about the earth, what would you think was the shape of the earth?

Look out as far as you can see. Look at the place where the earth and sky seem to meet. This is the horizon (ho-ry-z'n). Many people have believed the earth was flat. They thought the horizon was the end of the earth.

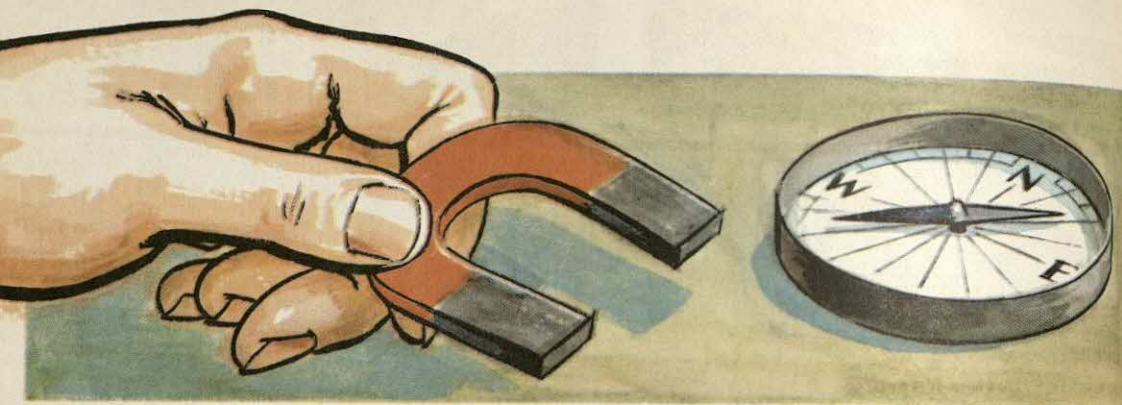
Now choose a higher place to view the horizon. This place may be a high window, the top of a fence, a tree, the top of a hill, the

side of a mountain, or the view from a plane. Is the horizon in the same place? How could you check? What happens to the horizon as you climb higher? What can your observation tell you about the shape of the earth?

Have you ever watched ships as they leave port and move out to the open water? The lake, sea, or ocean may look like a great flat stretch of water. At the horizon the sky and sea seem to meet.

Long ago, some people noticed that a ship seemed to sink into the sea as it sailed away. First the hull disappeared, and then the sails, little by little. Finally only the top of the mast could be seen. Then this too would disappear. What was happening? How would you explain it?





LOCATE

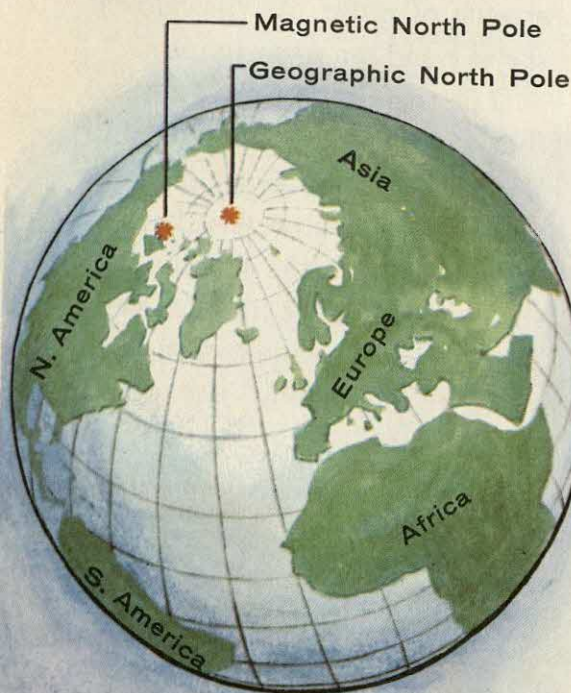
Have you ever watched the sky at night? How would you describe it? What do you see? Can you find the North Star? Use a compass to locate the northern part of the sky. On most compasses, the north pole of the compass needle is colored or marked in some way.

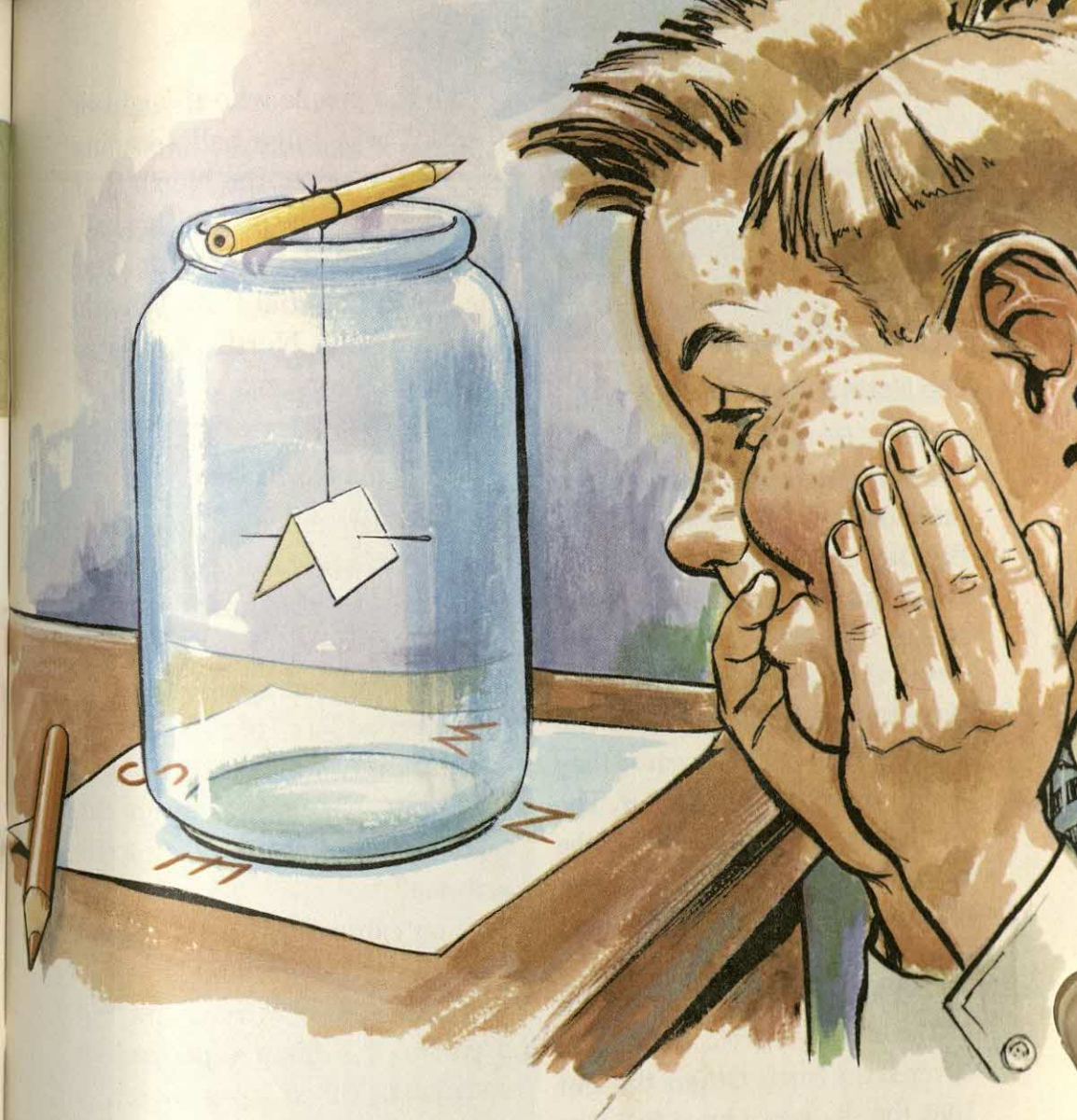
When a compass is not affected by a nearby magnet, its pointer always indicates north. The earth acts like a huge magnet with two poles. The north magnetic pole is in Canada. The south magnetic pole is in the Antarctic Ocean.

Expeditions to the North and South Poles have found that the magnetic poles are not located at the same places as the geographic poles. Which pole does the compass needle point to?

If the North Star is over the north geographic pole, will the compass point to the North Star? The compass will help you find the northern part of the sky.

If you don't have a compass, you can make one with a magnet. You know how to make a compass by floating a magnetized needle on water. Here is another way to make a compass. This one will be easier to handle outdoors.



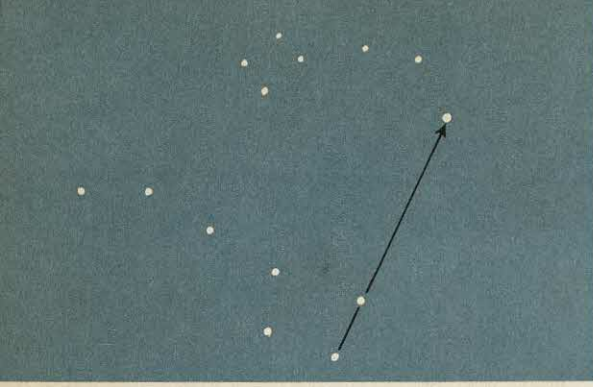


DISCOVER

Cut a two-inch square from an index card and fold it in half. Magnetize a large darning needle by stroking it with one end of a large bar magnet. Stroke in the same direction about 50 times. Put the needle through the card.

Thread another needle with fine thread, knotted at the end. Draw the thread through the center of the card. Suspend the card and needle in a jar, to keep them from blowing in a breeze.

How can you find out which end of the needle points north?



The North Pole of the Sky

Face in the direction of the north magnetic pole. Look up into the northern sky and find the Big Dipper. The picture of the Big Dipper on this page will help you. Notice the two stars with the arrow through them. Find these stars in the Big Dipper. We call them "pointer stars" because they point toward the North Star. The North Star is at the end of the Little Dipper's handle. Astronomers call the North Star "Polaris." Can you tell why?

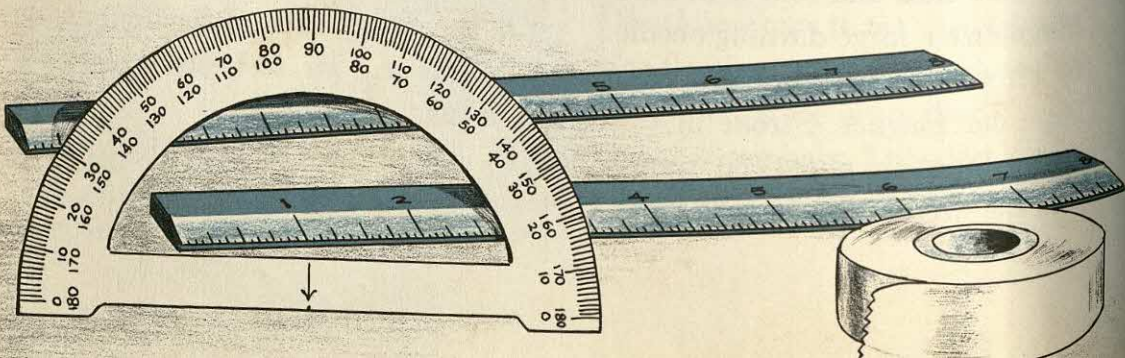
Some ancient people thought of the sky as a great dome that covered the earth. Others thought that the sky was a huge ball that surrounded the earth. Which idea do you think was better? Why?

To the people who thought of the sky as a huge ball spinning around the earth, the North Star was located at the pole of this ball. So they called the North Star the North Celestial Pole. Why do you think the North Star is so important?

Charting the North Star

How high above the horizon is the North Star? Look out straight from you to the horizon. Now look directly overhead. This point directly overhead is called the zenith (ZEE-nith). How far is the North Star from the zenith? How far is the North Star from the horizon? How can you find the answers?

You can make an instrument which will help you find the position of the North Star. You will need two flat rulers, tape, and an instrument called a protractor. A protractor is an instrument with which we can measure the size of angles.



EXAMINE

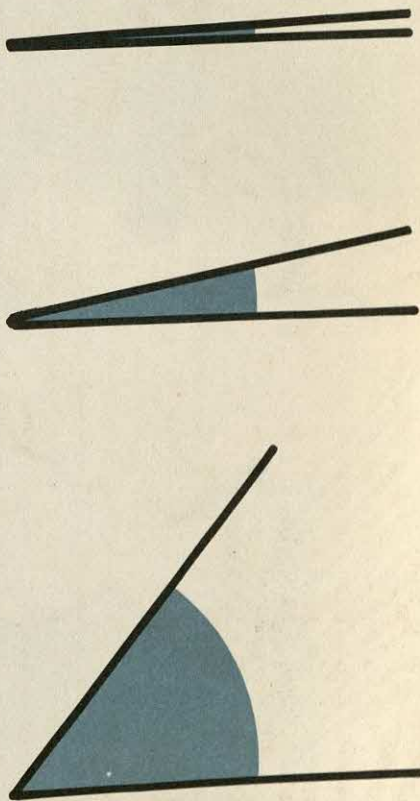
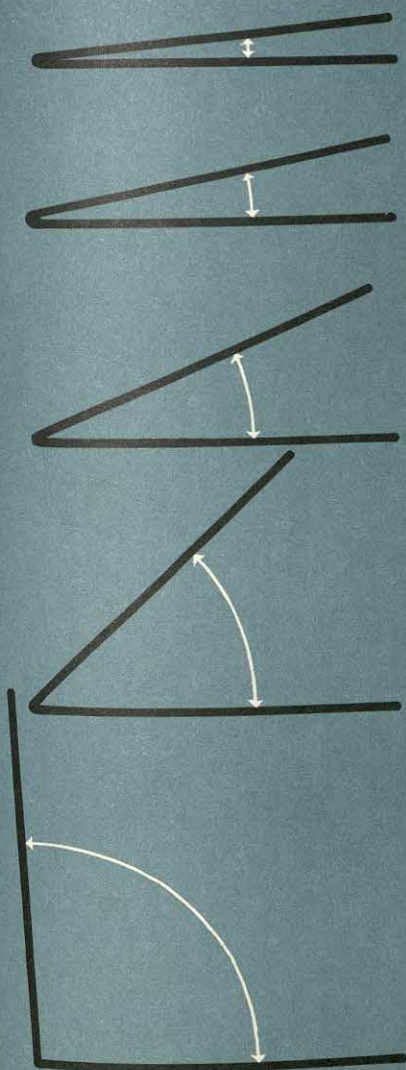
Some protractors look different than others. But protractors all are used in just about the same way.

There are many different angles, some large and some small. We define an angle as two rays

with a common end point. Examine the pictures. Notice how each angle depends on the two rays shown.

Which picture shows the largest angle? Which shows the smallest?

Angles are not measured in feet or inches or yards. One way angles are measured is by degrees. The symbol $^{\circ}$ stands for degrees.



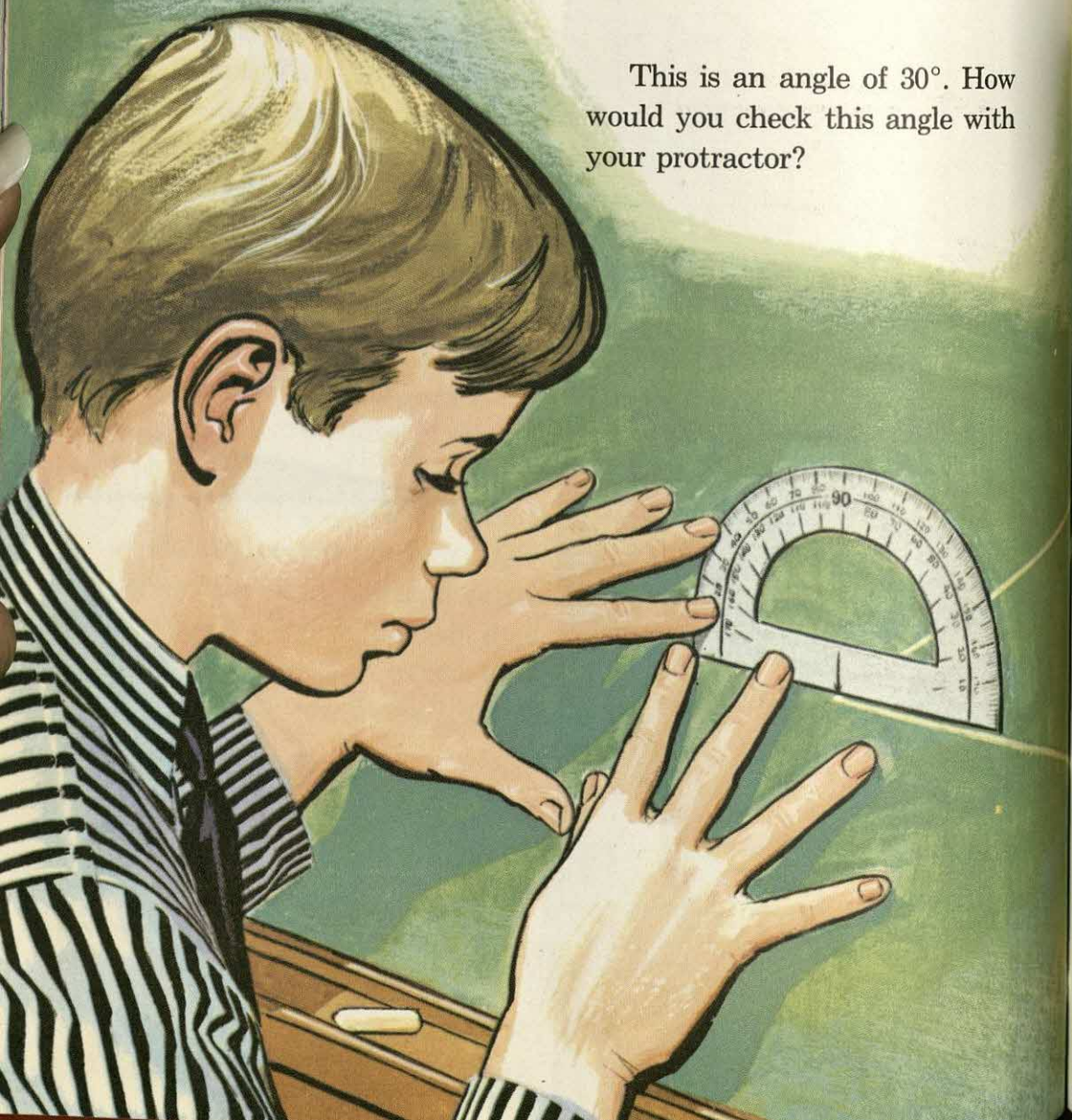
MEASURE

Use your protractor to practice measuring the angles pictured on this page and the next. Follow these directions.

Place the center marking on your protractor at the point where the two rays come to-

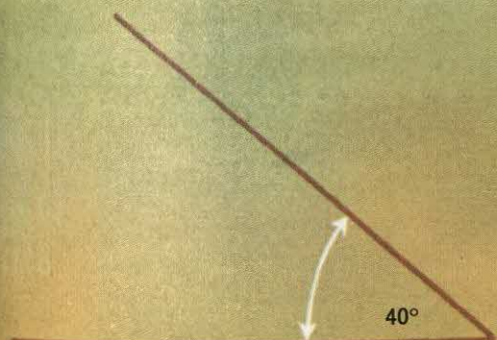
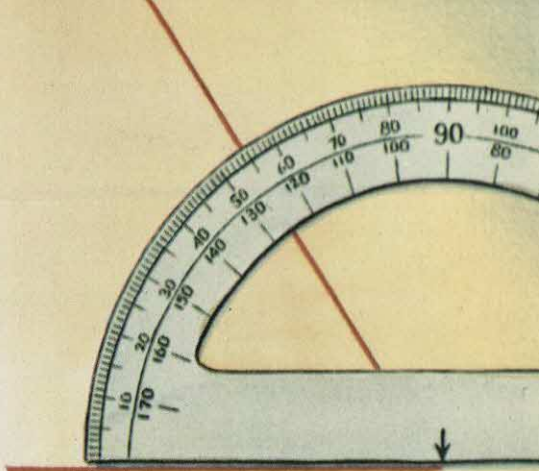
gether. Make sure the base of your protractor is placed along one of the sides of the angle. Look at the numerals where the other straight line passes by the outer edge of your protractor. These numerals name the number of degrees in the angle.

This is an angle of 30° . How would you check this angle with your protractor?

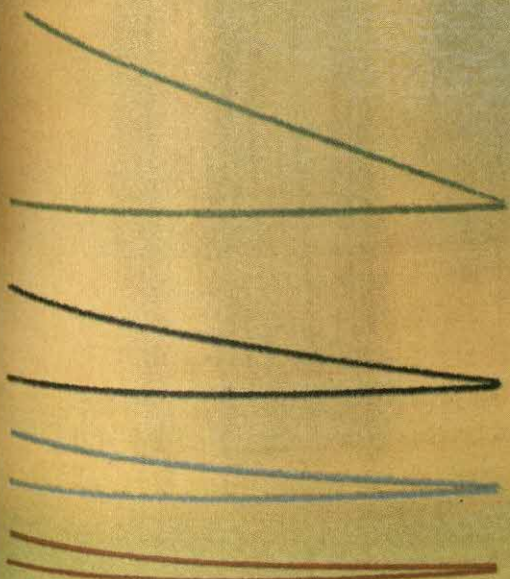


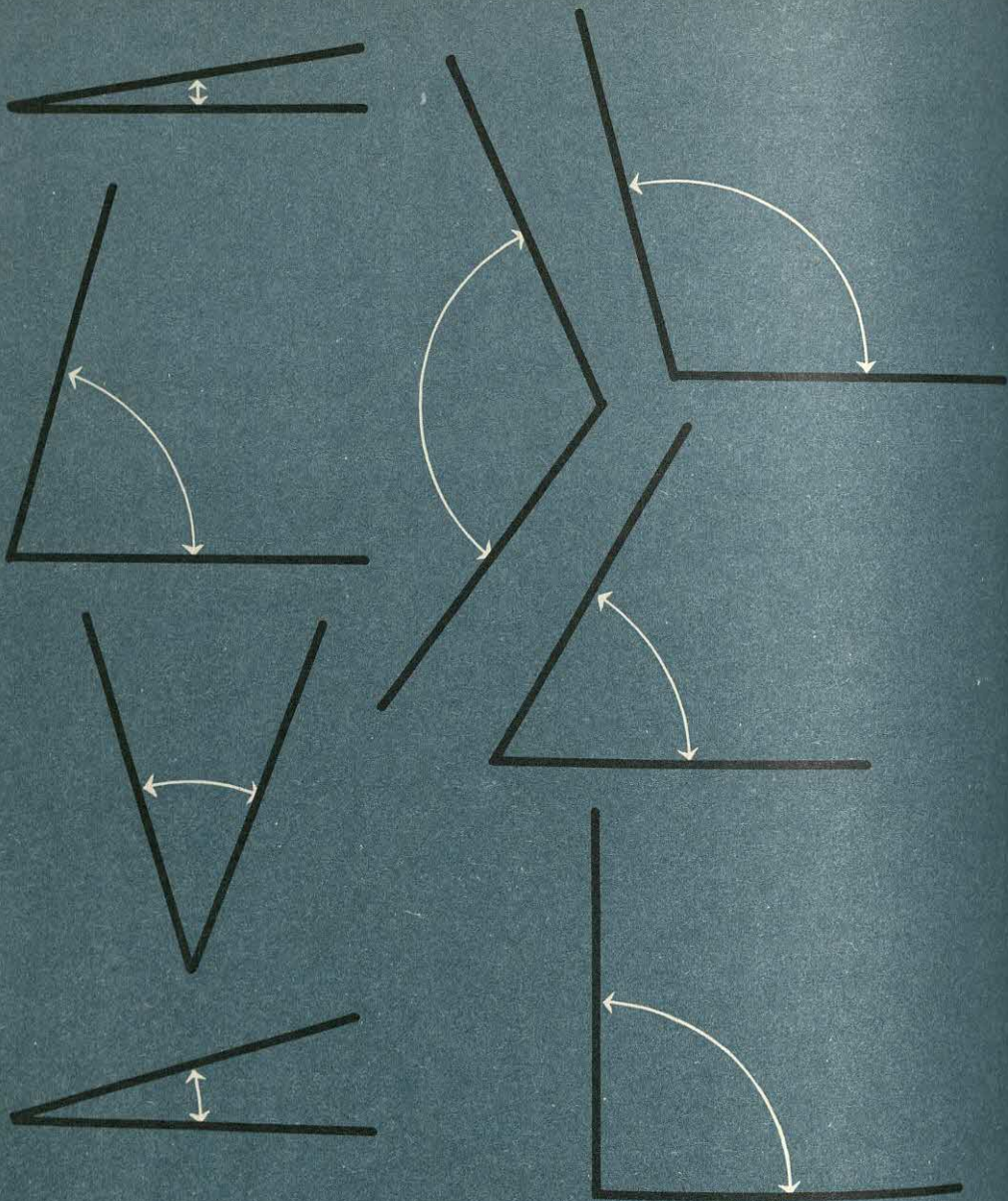
MEASURE

To measure these angles, place the center marking of your protractor at the point where the two rays come together. Line up the base of your protractor with one of the sides. Now, on the inside markings of your protractor, read where the other side meets your protractor.



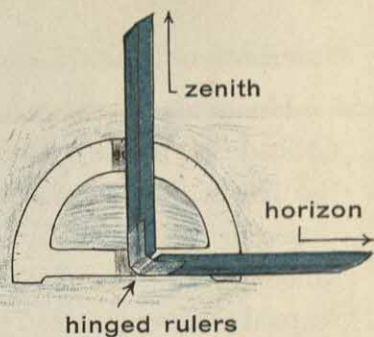
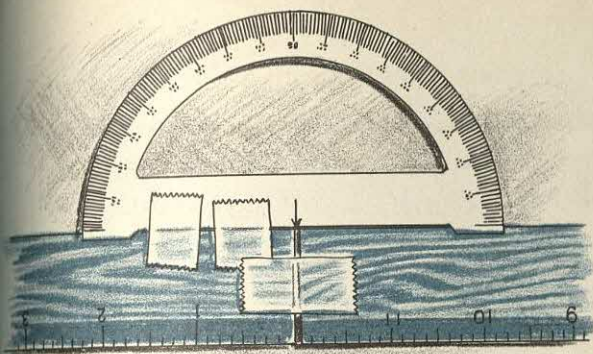
This is a 40° angle. What are the other angles pictured?





Your protractor is like a half circle. How many degrees are there in a half circle? How many in a whole circle? When the two

sides of an angle come together to form a square corner, how large is the angle? How many degrees are there? □ □



OBSERVE

You have practiced using your protractor. Now you can make the instrument to help you find the position of the North Star.

Place the rulers end to end and tape the ends together. The tape forms a hinge so that the rulers can fold together.

Hold one ruler so that it points straight out to the horizon. Point the other to the zenith. The rulers now form a square corner.

Tape the protractor to your rulers so that the base of the protractor is on the horizon line and the zenith line cuts the 90° mark. You are ready to measure the position of the North Star.

Hold the rulers at eye level. Be sure they point straight out to the horizon. Now look at the North Star. Point the top ruler at the star. How many degrees above the horizon is the North Star?



This is the altitude of the North Star for the place where you live.

Fasten a flat stick or a metal or plastic tube to a tree or post so that it points to the North Star. Sight along the stick or tube to check the position of the North Star every clear night for a week. Does the position of the North Star change?

Flat Earth or Round Earth?

Hundreds of years ago, sailors noticed that as they sailed north, the North Star seemed to move closer to the zenith. When they sailed south, the North Star seemed to move closer to the horizon. Do you think the North Star would change its position in the sky if the earth were flat?

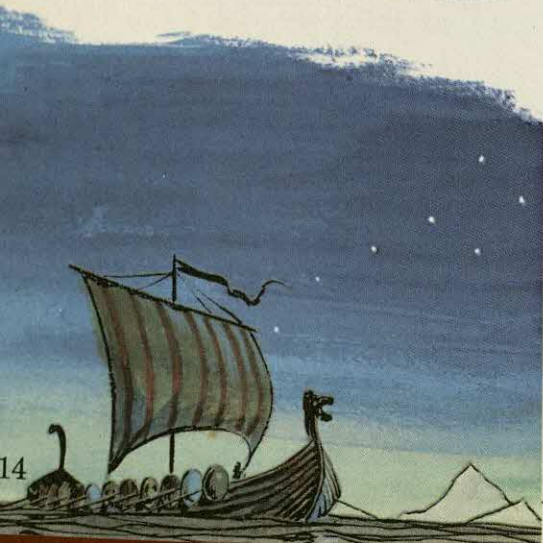
As early as four hundred years before Christ, some men believed that the earth was round. These men had observed how the horizon seemed to move farther away as they climbed a hill or a mountain. They listened to the tales of travelers. The travelers told how the North Star seemed to change its position in the sky as their ships or caravans moved north or south.

Travelers had learned to use the North Star as their guide at night. They also used an instru-

ment something like the one you made. What would be the reading of your instrument if you went to the North Pole? What would it be if you went to the equator? The altitude of the North Star above the horizon gives the latitude of the place on the earth where the reading is taken.

Many people found it hard to believe that the earth was round. How could people stay on a round earth, they asked. Why wouldn't water run off the earth? They went on believing that the earth was flat.

There were other people who watched the sky and watched the horizon and found it hard to believe that the earth could be flat. These sky watchers had another reason to wonder about the shape of the earth. Have you read about eclipses? What happens when there is an eclipse of the moon? What shape is the shadow of the earth on the moon?





EXPLORE

Do all objects throw the same kind of shadow? Look and see.

Shine a projector or flashlight at a screen or a wall. Hold a tennis ball in the path of the light beam. What shape is its shadow? Move the tennis ball in and out of the light beam. Tell what you see.

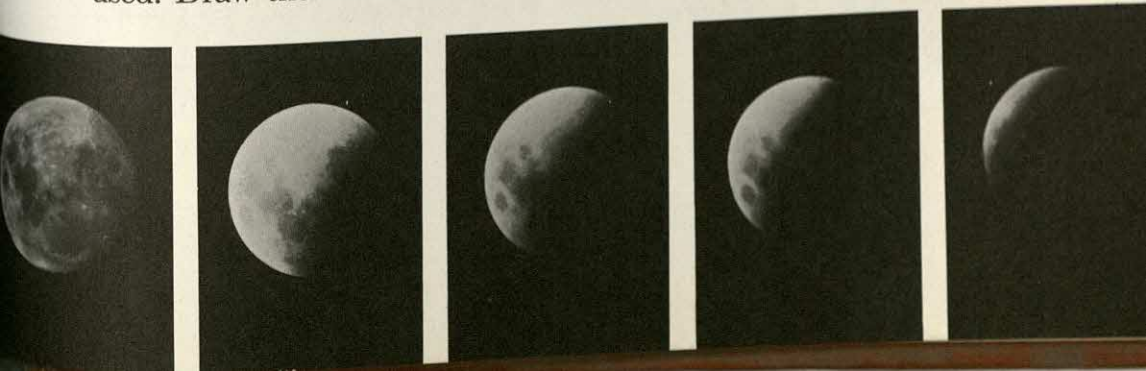
Take a cube of wood, a tin can, a jar lid, and a sausage. Hold each one in the path of the light beam. What are the shapes of the shadows? Objects that block light are called opaque (o-PAYK). Hold some other opaque objects in the light beam. What do you see?

Make a list of the objects you used. Draw their shadows along-

side their names. Turn each object in the light beam. Tell what happens to the shape of the shadows. What happens to the shadow of the tennis ball?

Hold a ping-pong ball, a tennis ball, and a globe in the light beam. What is the shape of the shadow of each on the other?

When the earth comes between the sun and the moon, the shadow of the earth sometimes falls on the moon. We can see this from the earth. Examine the photographs of the moon eclipse. What can an eclipse of the moon tell us about the earth's shape?



Eratosthenes

Over two thousand years ago a man used shadows in another way to find out about the shape of the earth. This man's name was Eratosthenes (*er-a-tos-the-neez*). He was a Greek citizen who lived in the city of Alexandria, in Egypt. Eratosthenes was a librarian and a scientist. He read that at noon on the longest day of the year the bottom of a well in a city called Syene was filled with sunlight. There were no shadows in the well. How did this information tell him that the sun was directly overhead at Syene on the longest day of the year?

Look for Alexandria on a map of Egypt (the United Arab Republic). You will not find Syene on a modern map of Egypt. Look instead for Aswan, which is at about the same place.

Was the sun at the zenith at Alexandria on that same day at noon? Eratosthenes had never observed the sun to be directly overhead at noon on any day. Have you? Turn your back to the sun at noon. Do you have a shadow? Is the sun at the zenith? Where is the sun located in the sky? How could you locate it?



DESCRIBE

What is the effect of the location of a light source on the shadow that is formed?

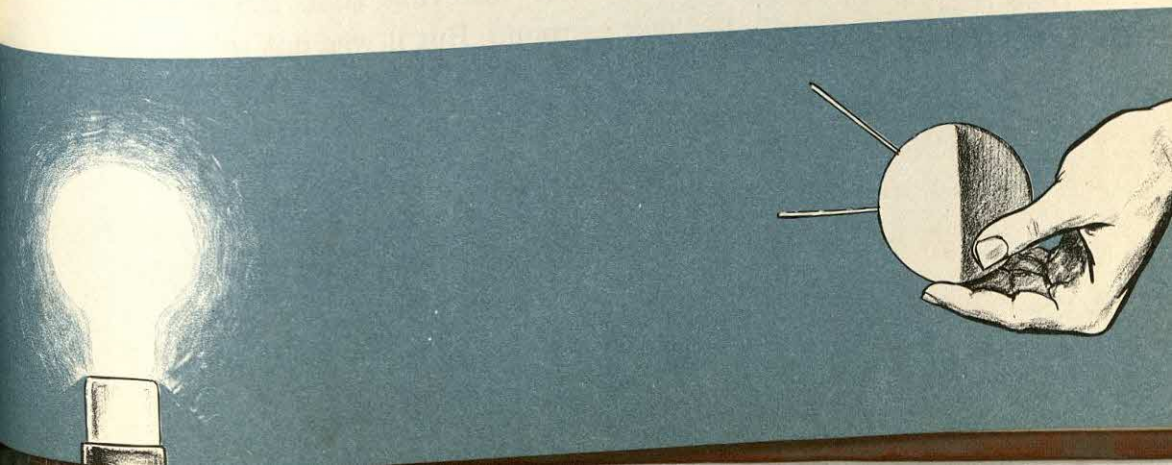
Support two pencils upright by sticking them into some modeling clay. Hold a flashlight or a lamp directly above the pencils, at a distance of two feet. Where are the shadows? Slant one pencil. What happens to its shadow? Repeat the activity, holding the light a few inches above the pencils. Is there a difference? Why?

Use a ball of sponge rubber, or make a ball of clay. Stick one toothpick into the middle of the ball. Call this toothpick "A." Stick another into the ball at a point halfway to the top. Call this toothpick "B."

Hold the ball in front of a lamp. The picture below shows how to arrange the ball and toothpicks in position with the lamp. What is the shadow at "B"? What is the shadow at "A"?



Have the lamp level with the ball, but at a distance from it. Turn the ball and watch the shadows of the toothpicks. What happens to the shadows?





ACTIVITY

Find Aswan on a globe, and use modeling clay to support a toothpick at this point. Because your globe is a very small model of the earth, you will have to place your second toothpick farther north than Alexandria. Place it about three inches north of Aswan.

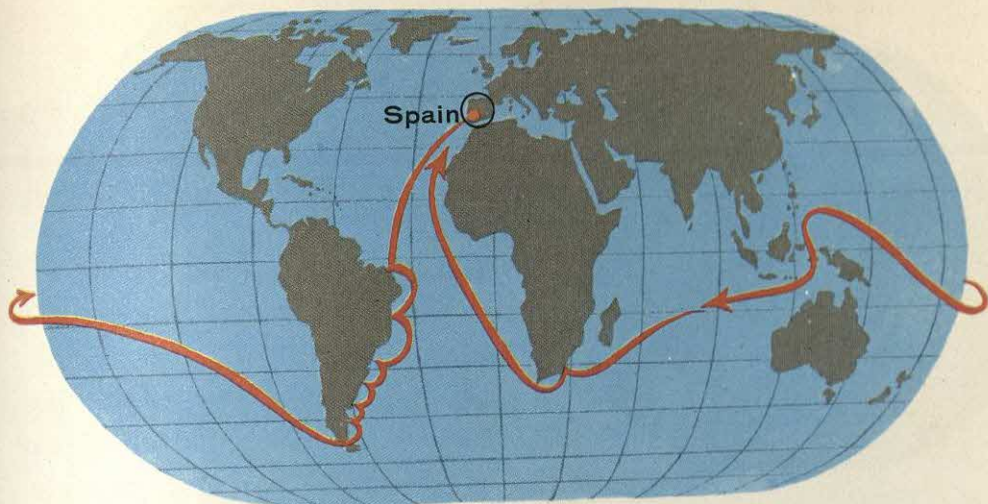
Now move the globe so that the axis is tilted toward the lamp. Arrange the lamp so that the light shines directly on the toothpick at Aswan (Syene). Look at the shadows. What do you see?

Take a stiff cardboard. This

will represent a flat earth. Support two toothpicks on the cardboard, three inches apart. Turn on the lamp and study the shadows of the toothpicks. Why did Eratosthenes believe that the earth was round?

Exploring the Earth

Eratosthenes had good reasons for believing that the earth is round. But it was not till the sixteenth century that a man's own experience gave some proof that the earth is round. In 1519, an explorer named Magellan set sail from Spain with five ships. Magel-



lan and his brave sailors wanted to try to sail all the way around the earth. The voyage was a long, hard, dangerous one. Four of the ships were sunk, and Magellan and many of his men died. But at last, three years later, one of the ships returned home to Spain.

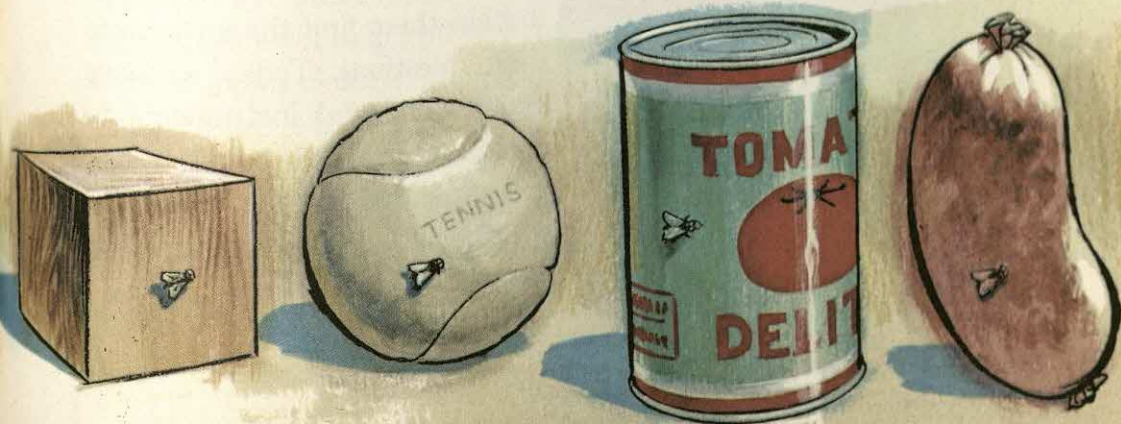
PREDICT

If a man can travel around the earth and come back to the same point from which he started, does he prove that the earth is shaped like a ball? Examine a cube of

wood. What might happen to a fly if it walked in a straight line around the sides of the cube? Would the fly arrive back at the point from which it started?

What would happen if the fly walked in a straight line around the middle of a tin can or a sausage? What would happen if the fly walked in a straight line around a tennis ball?

Did Magellan's voyage prove that the earth is round? What would have to be done to prove the exact shape of the earth?





The Shape of the Earth

Do we know now that the earth is round? How do we know?

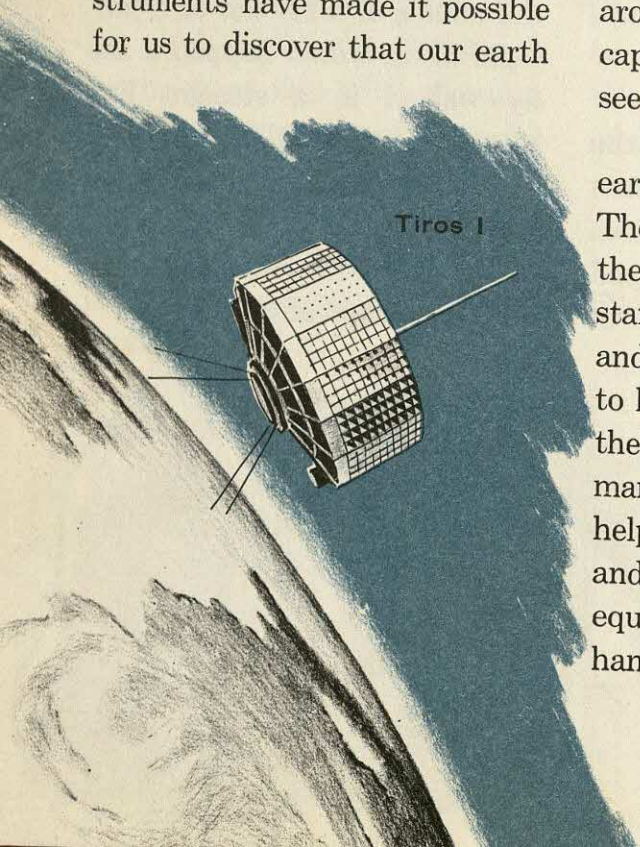
A body that is perfectly round like a ball is called a sphere (SFEER). We generally say that our earth is a sphere. Modern instruments have made it possible for us to discover that our earth

is not exactly a sphere. It is flattened a little at top and bottom—at the North and South Poles. It bulges a little below the equator. But the picture at the left is exaggerated. The earth's shape is not so uneven as this.

One of the inventions that has helped us to learn about the shape of the earth is the space satellite. Some satellites carry instruments, while others carry both instruments and men.

Weather satellites like Tiros (TY-rohs) take pictures of the earth and broadcast them back to stations on the ground. Astronauts and cosmonauts travel around the earth in their space capsules. They can look out and see the shape of the earth.

Long ago, men stood on the earth and looked up at the skies. They asked many questions about the earth and the sun and the stars. They had only their eyes and their hands and their minds to help them find the answers to their questions. Today we have many wonderful instruments to help us learn about the earth, sun, and stars. But our most important equipment is still our eyes and our hands and our minds.





Time and Distances

Sometimes a model helps you to understand something you cannot see. You cannot see our solar system and how it works because some of the objects in it are too far away. But a model of our solar system will help you understand it more clearly. There are many things which you cannot learn about our solar system unless you have a picture of the solar system in your mind.

Scientists often picture in their

minds ideas which cannot be seen. These ideas are sometimes called theories. There have been many scientists with theories about our solar system. These scientists used models to show others the ideas they had in their minds.

Not all theories are correct, but all honest theories try to help people understand the world around them. Theories can change when scientists get more information. Some theories help build newer and better theories.

Some ideas in scientists' minds are called concepts. Concepts are not like theories. Concepts are ideas which help scientists understand other ideas. It takes many concepts to make a theory.

Concepts are very important to have for they help you to better understand what you see, read, and hear.

For example, you have heard people talk about the number one million. We write 1,000,000 to name the number one million. Do you have a picture of the number in your mind?

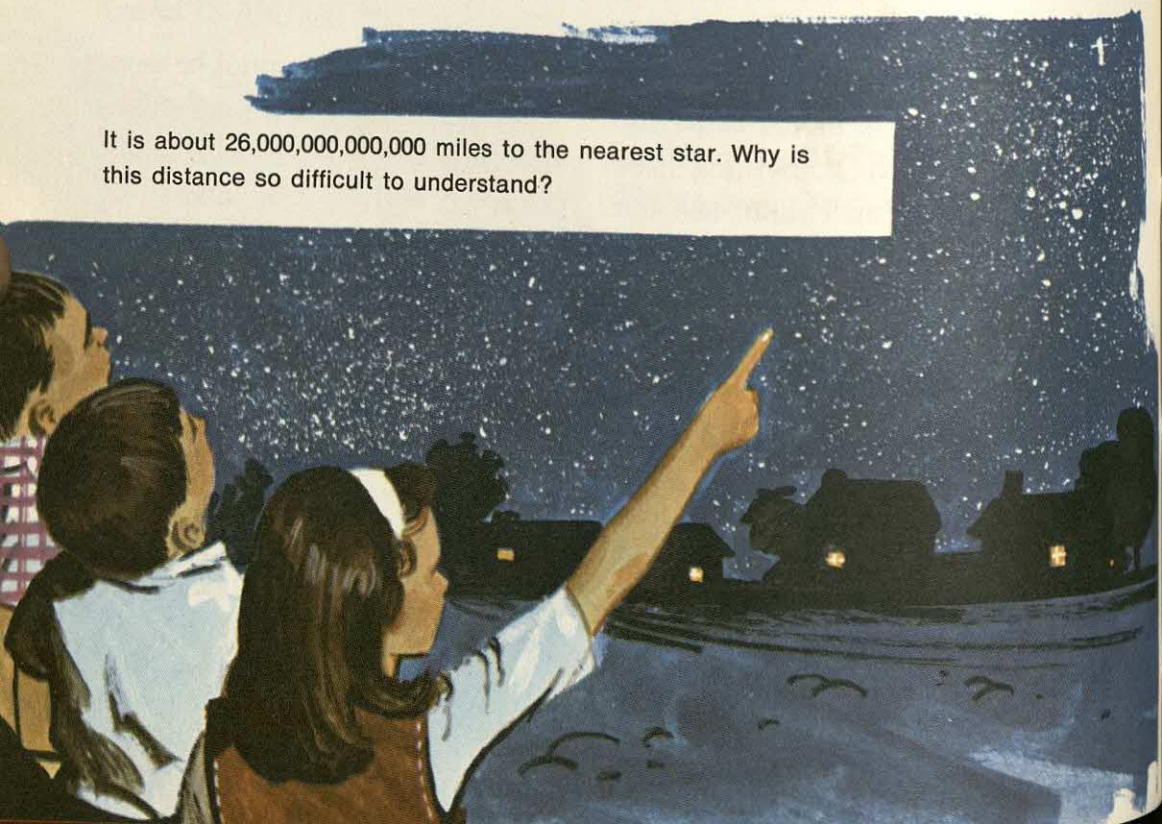
Most people do not have a concept for 1,000,000. Many people

talk about the number but they don't really understand what they are saying unless they have a picture of it in their minds.

If a person spent \$1,000,000 would you really know how much money he spent? If an astronomer said there is an object in space that is 1,000,000 miles away, would you really know how far away it was?

Astronomers have a good concept about very large numbers. Do you? On the next few pages you will see models or pictures which represent very large numbers. These models will help you understand large numbers.

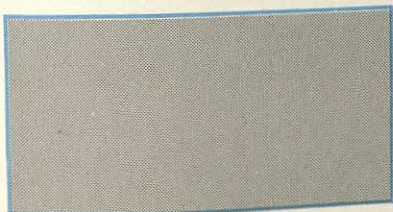
It is about 26,000,000,000,000 miles to the nearest star. Why is this distance so difficult to understand?

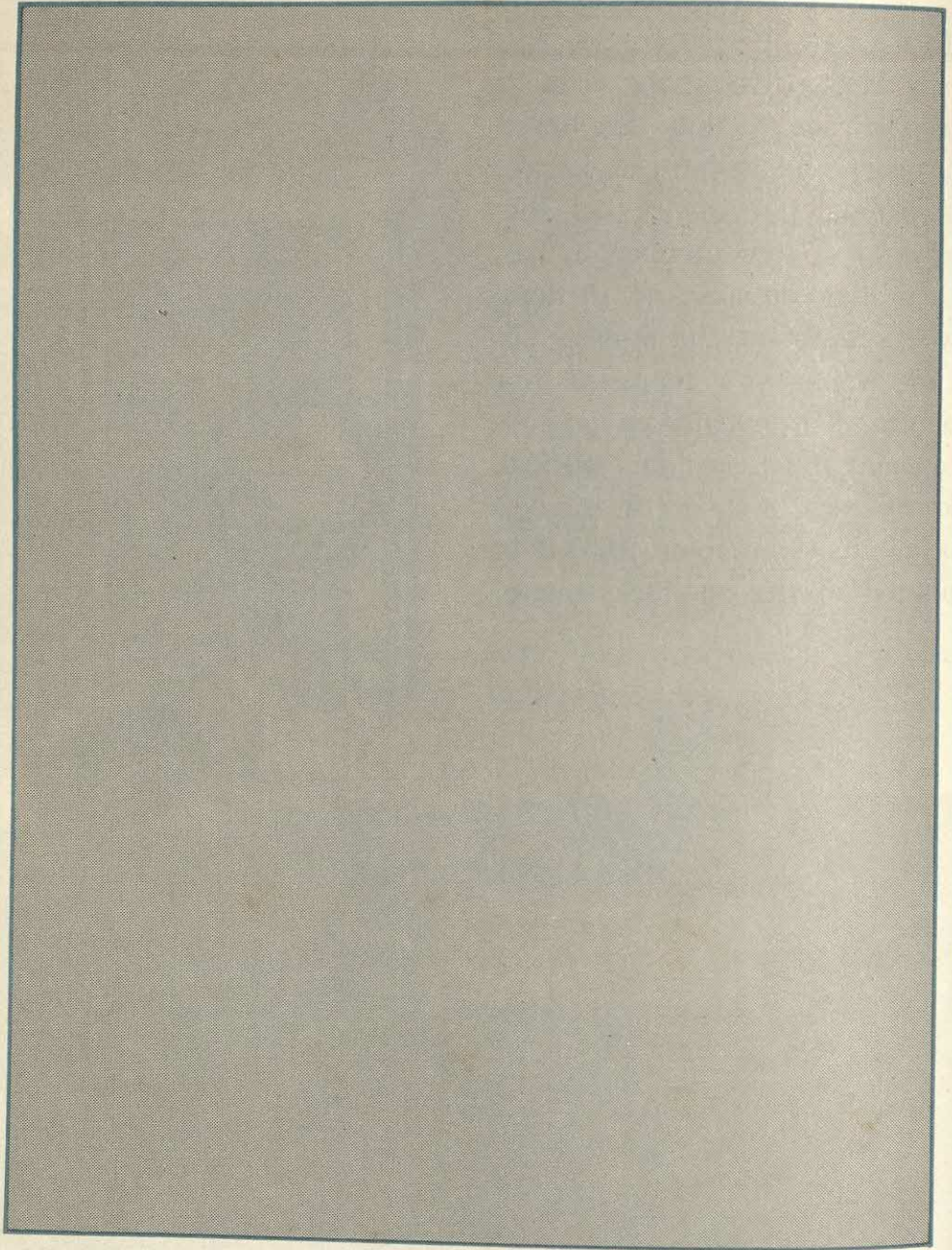


Below is a grey 1"x1" box. Take a very close look at it. You may need a magnifying glass to help you see the dots. Try to see as many dots as you can. Locate a single dot. Pretend that this tiny dot is the number 1. Ten times this number, or 10 dots, would represent the number 10. How would you represent the number 100? 1,000? Are you able to count this many dots without losing track of them? In the box below there are about 3,600 dots printed in the one-inch square.



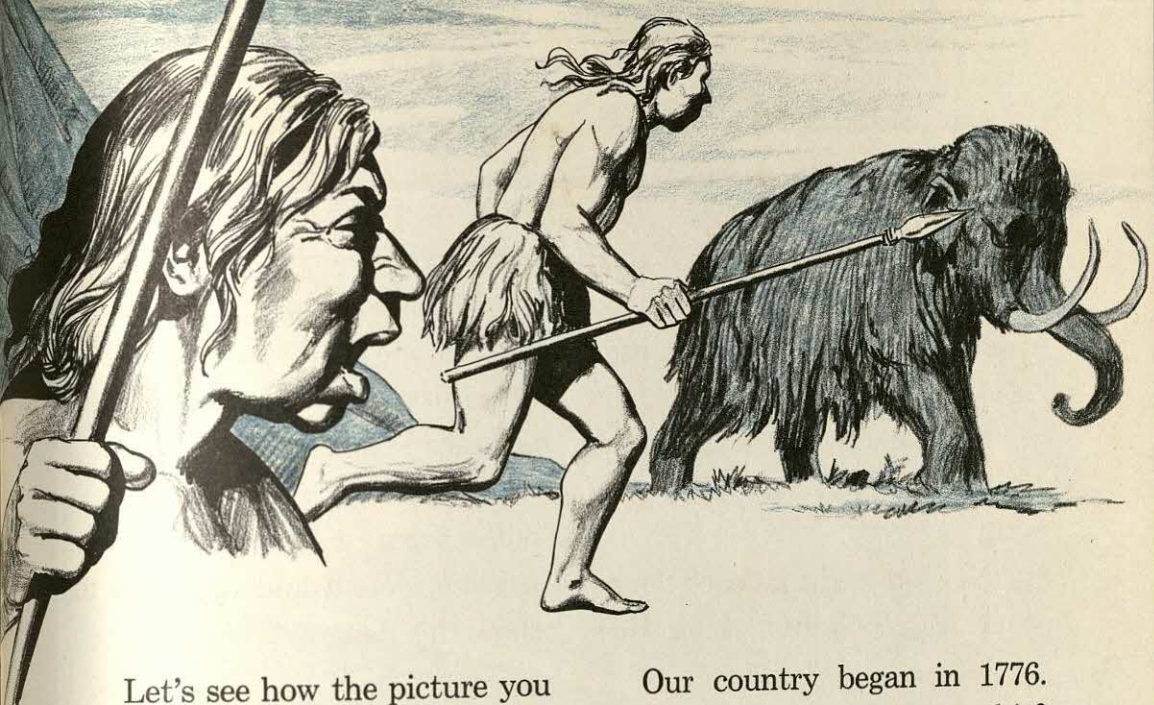
How many dots would there be in a box this big?





There are about 100,000 dots printed on this page. Look at them with a magnifying glass.

How many pages of this kind would you have to look at in order to see one million dots?



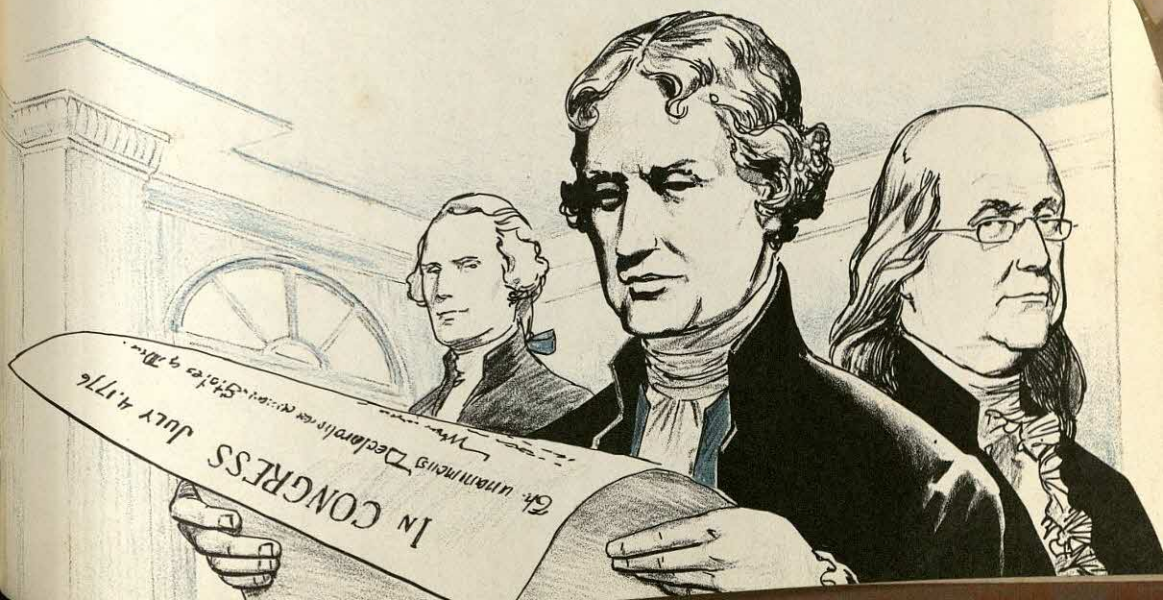
Let's see how the picture you have in your mind of 1,000,000 can be used to understand other ideas.

Pretend that 1 dot on page 224 represents 1 year. How many years would all the dots represent?

How old are you? How many dots out of 100,000 dots represent your age?

Our country began in 1776. How many years ago was this? Cover the number of dots which represent the age of our country with a piece of paper.

Many scientists believe that the first cave dwellers lived about 50,000 years ago. Cover this many dots and compare them with 100,000.



Our earth is very old. Scientists estimate the age of the earth to be 4,500,000,000 (four and a half billion) years. If each dot represents one year, you would need 4,500 pages like page 224 to show the age of the earth.

Compared with the age of the earth, have you been alive very long?

Now pretend that each dot on page 224 represents 1 mile. How

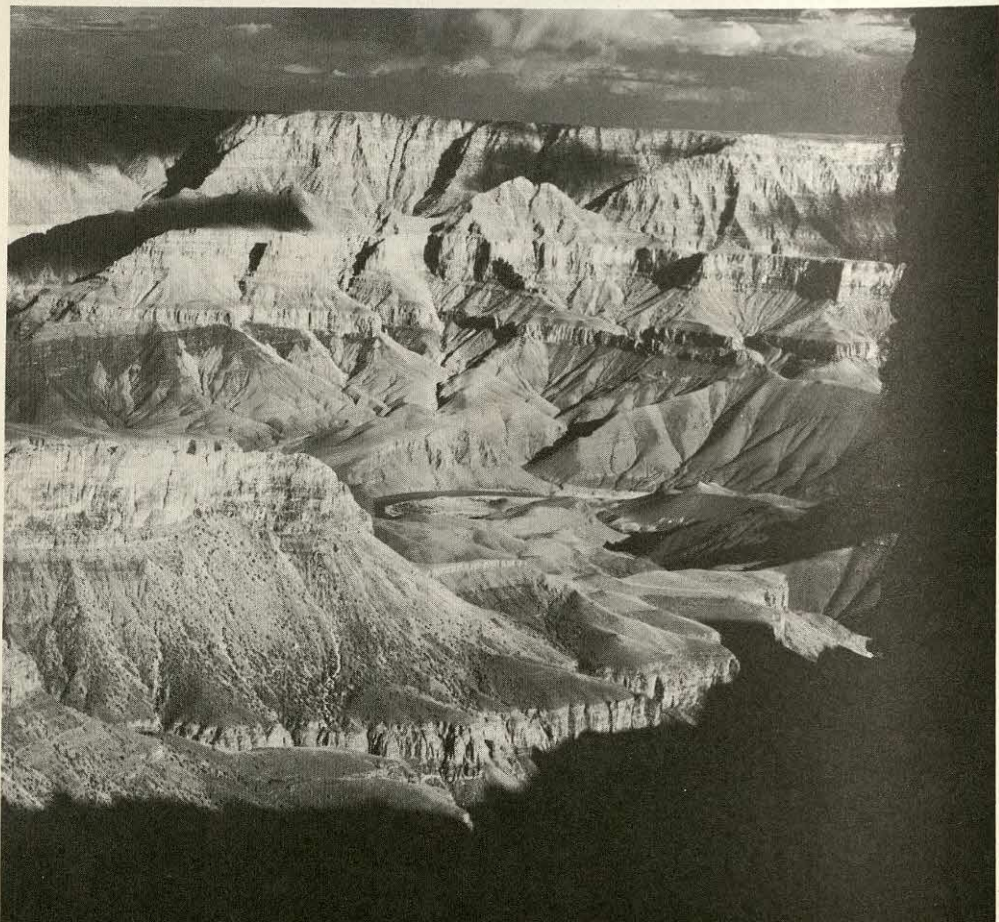
many miles would all the dots on that page represent?

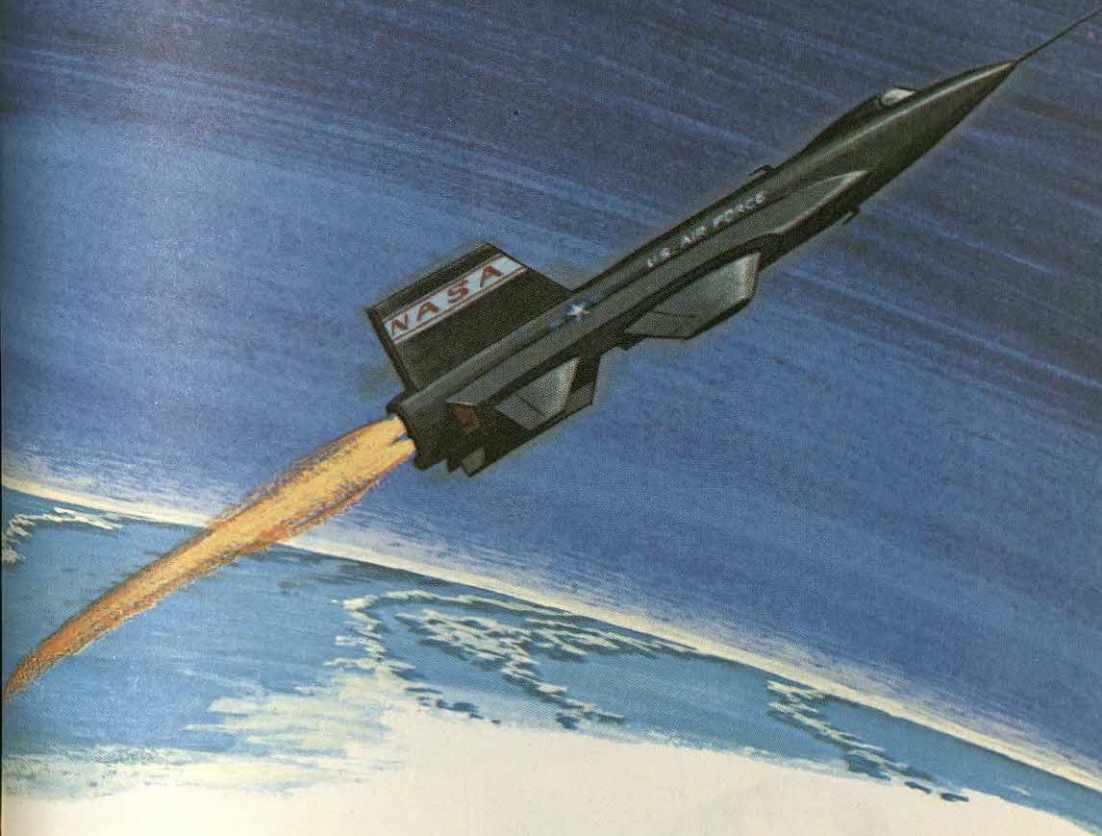
If you traveled around our earth, you would travel about 24,000 miles.

Our moon is about 237,000 miles from earth. Compare this distance with 1,000,000 miles.

Our sun is about 93,000,000 miles from earth. How many pages of dots would you need to show this distance?

These Grand Canyon rocks show the earth's aging. How many pages of dots are needed to show the age of these rocks formed almost 600 million years ago?





Our fastest rocket plane can travel faster than 4,000 miles per hour. If it could fly all day and all night at this speed, it would travel about 100,000 miles per day. If you can imagine each dot on page 224 measuring one mile across, you would have some idea of a distance of 100,000 miles. Compare the distance the rocket plane could travel in a day with the distance to the moon and the distance to the sun.

How long would it take to fly to Mars, which is about 49,000,000

miles from earth?

By now you should have a better concept about time and about distances in outer space. But one small change in your concept should be made. It is important to remember that time and distance are usually thought of as straight lines. The dots on the previous pages are not in a straight line. They are grouped together. To better represent 100,000 miles, for example, the dots should be arranged along one long line. How long would this line be?

Motion in the Sky

Look at the Sky

When men of long ago looked up at the sky, what did they see? What do you see when you look at the sky during the day? What do you see in the sky at night?

The Sun and the Moon

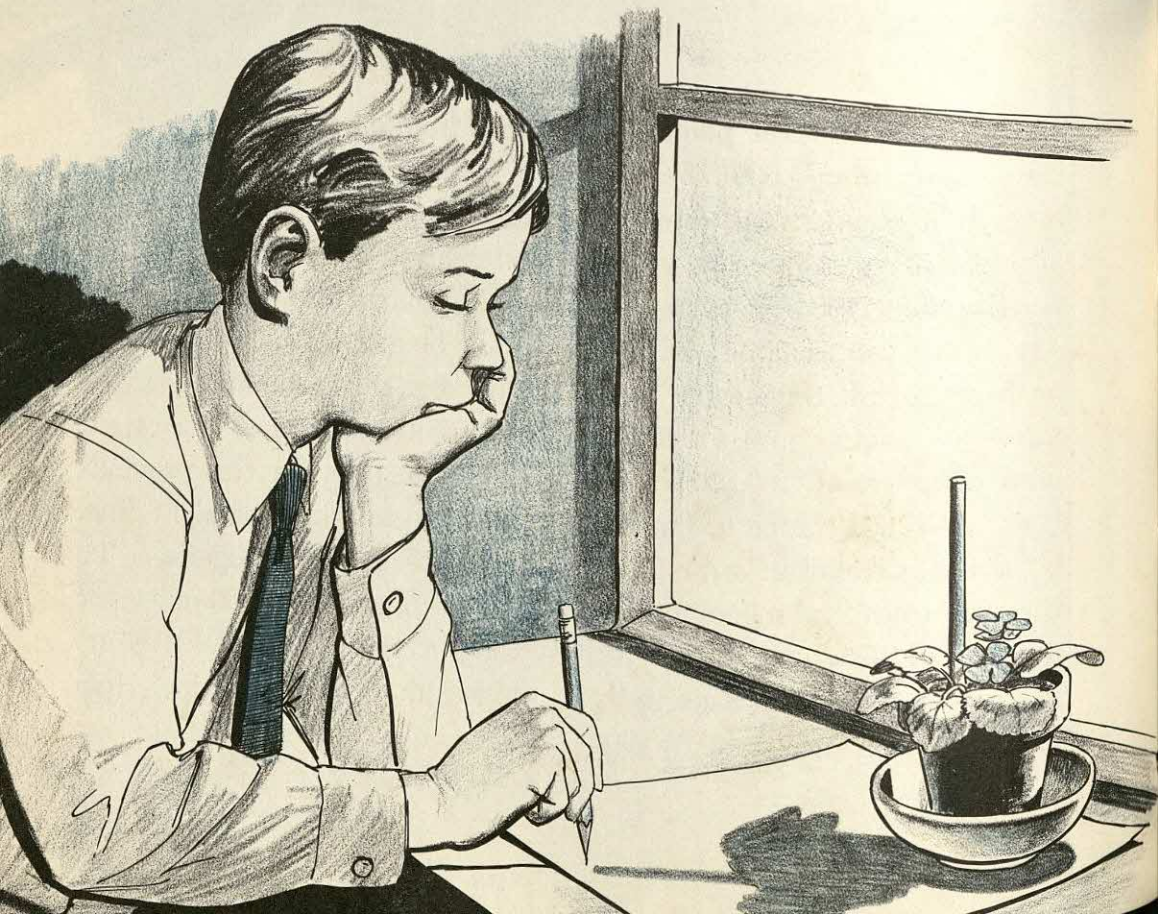
In what part of the sky do you first see the sun in the morning? In what part of the sky do you last see the sun in the evening? Where is the sun at night?

Does the sun seem to move through the same path in the sky

every day? Does the sun move? Is the sun in the same place in the sky at the same time every day of the year? Let's check.

CHECK

Push a pencil, point up, firmly into the earth of a flower pot. Place the flower pot on a sheet of paper on a sunny windowsill in your classroom. Do not move it again until this whole activity is finished. Mark a dot at the tip of the pencil's shadow every day at the same time for a month.





If the sun travels the same path each day, what do you expect to find on the paper? Does the sun travel the same path each day? How do you know?

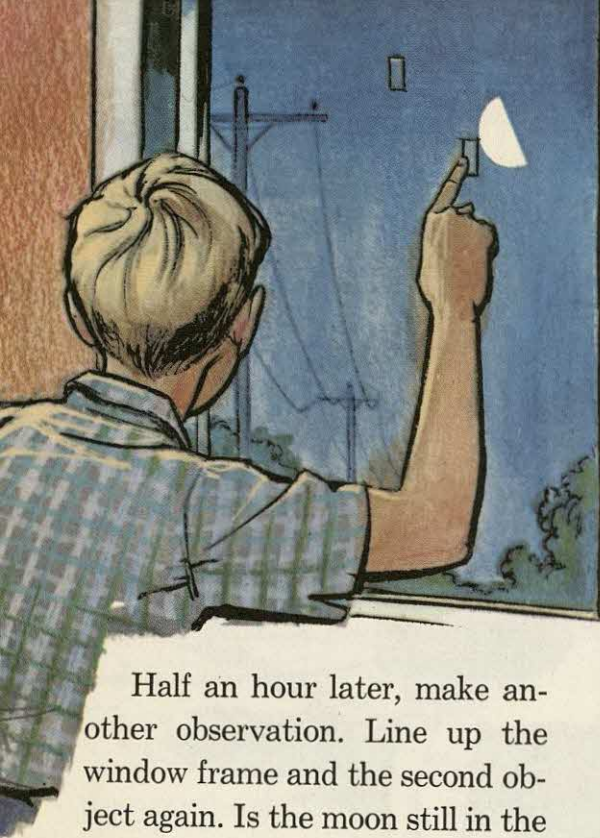
If you have a flagpole or a tall tree in the schoolyard, you can use the shadow of the pole or tree to learn more about the sun and how it seems to move. Every morning at the same time, mark the end of the flagpole's shadow. Use a string and mark it off if the pole is in concrete. Plant a stake

if it is on a lawn. What do you discover after a week? A month?

OBSERVE

Look at the night sky. Does the moon stay in the same place?

On a clear night, choose a window from which you can see the moon. Line up the edge of the window frame with an object outdoors, such as a tree, a telephone pole, or the edge of a building. Then mark the moon's position on the window pane with tape.



Half an hour later, make another observation. Line up the window frame and the second object again. Is the moon still in the same position as when you made your first observation?

The Stars

Do the stars stay in the same place in the sky? Find the North Star. Use your finder on the tree or pole. Note the position of the Big Dipper. An hour later, check the position of the Big Dipper with that of the North Star.

EXPLORE

Draw a circle and divide it into four parts. Put a star in the center of the circle. This is the North Star. In each of the four parts of the circle, draw the Big Dipper.

Make sure the pointer stars are in a line with the North Star each time. Number your dippers one, two, three, and four.

Observe the sky tonight. Hold your paper circle so that dipper 1 is in the same position as the Big Dipper in the sky. Mark the time in the block. At what time do you predict the Big Dipper will be in position 2 on your circle? How can you check your prediction? Where will the Big Dipper be in the daytime? Why can you not see the stars in the daytime?

Make a model of the northern sky on the inside of an umbrella. Which of the northern constellations do you know? Look between Cassiopeia and the Little Dipper for Cepheus (SEE-foos). Cepheus is shaped like a little house.

Make pictures of the northern constellations with silver stars on black paper. Tape the pictures to



the inside of an umbrella. Check their positions in the sky to be sure you are placing the constellations correctly.

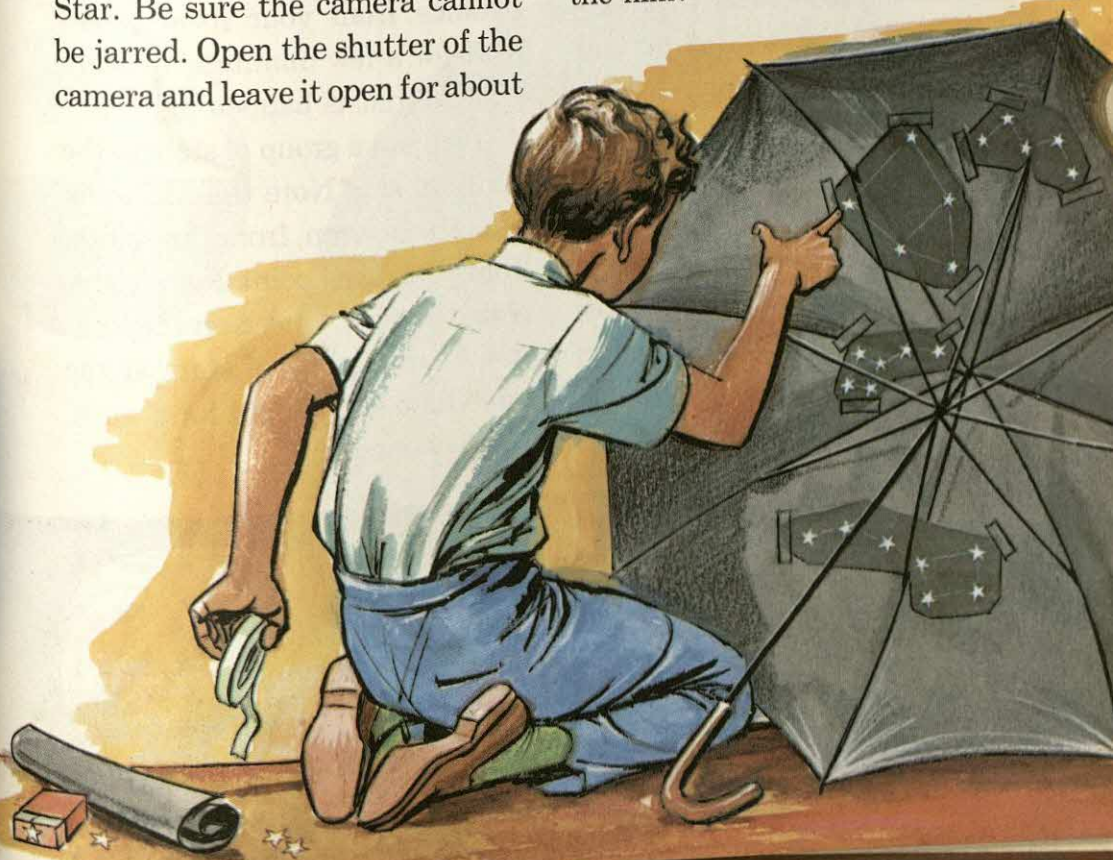
Turn the umbrella to show where the constellations will be at the different hours of the night. How long does it take these stars to make one rotation? Use your umbrella and watch the sky. What can you discover about the movement of the stars?

If you have a camera that can be fixed for a time exposure, take a picture of the night sky. On a clear night, set the camera on a steady support outdoors and point the camera to the North Star. Be sure the camera cannot be jarred. Open the shutter of the camera and leave it open for about



an hour. Then close the shutter and have the film developed. What do you find? What does the picture tell you about the way the stars seem to move?

Look at the photograph of the night sky, taken with the camera pointed at the north celestial pole. Where is the North Star? How long was the film exposed for each star to trace a quarter-circle on the film?





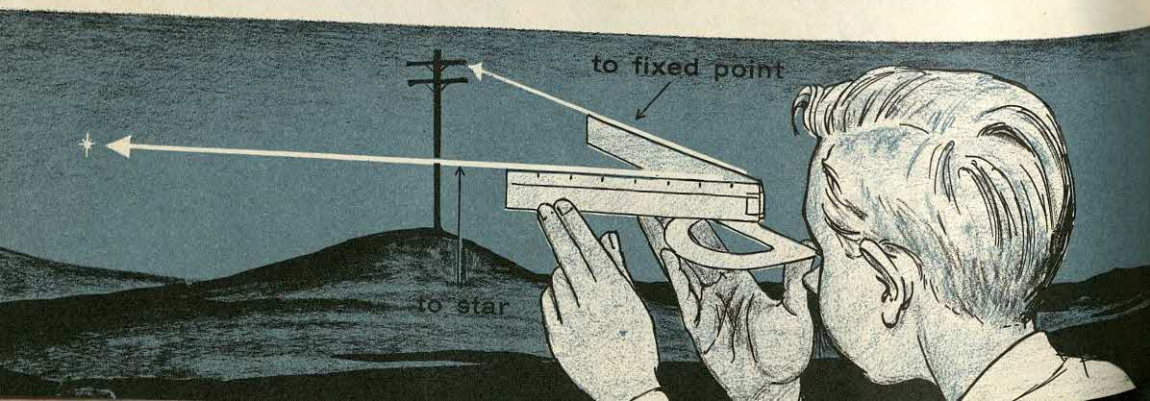
ACTIVITY

With six or seven of your classmates, line up side by side in the schoolyard, holding hands. Let a boy at one end of the line act as the pivot point while the others walk around so as to make a complete circle. Did the pivot boy move? Did he move as much as the others? Why do we call the North Star a “fixed star”?

How do the stars in the southern sky move? There is no “fixed star” in the southern sky, so you must choose a fixed point. Choose a fixed point to your right. This point may be a tree, a telephone

pole, or the corner of a house. Sit or stand very still. Rest your head against some object to keep it from moving. Choose a star located near your fixed point. Use your instrument to measure its distance from your fixed point. Wait for a few minutes. Measure again. What is happening?

Pick out a group of stars in the southern sky. Note their location from the horizon, from the zenith, from your fixed point at the right. Note the time. Check on the location of this group of stars at the same time every night for a week. What is moving?



EXAMINE

Would you see the same stars in the sky in South America as you do here? Could you see the North Star? Examine the picture on this page. The earth is marked off into two parts. Each part is called a hemisphere (HEM-i-sfeer), which means half a sphere. The part from the equator to the North Pole is called the Northern Hemisphere. The part from the equator to the South Pole is called the Southern Hemisphere. In which hemisphere is most of South America? In which hemi-

sphere is Hawaii? Do the children in South America see the same stars as you do? Why?

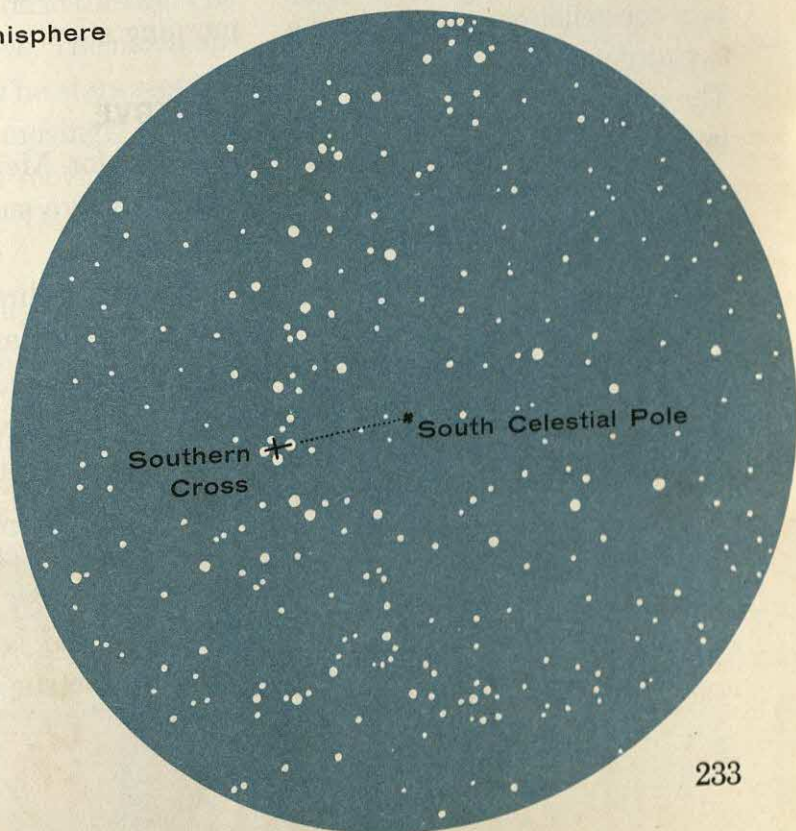
There is no bright star near the south celestial pole. However, the Southern Cross is not too far from the south celestial pole. It is easy to recognize. People living in the Southern Hemisphere use the Southern Cross as we use Polaris. Find the Southern Cross on the star map.

Why do you think it is not possible for us to see the entire heavens when we look out into space?

Northern Hemisphere



Southern Hemisphere





Order in the Sky

Today, pilots and sailors have many instruments to keep them on course. But in case anything should happen to their modern instruments, they can always go back to the old ways of finding direction from the stars.

The stars are useful guides to the traveler because they keep the same positions in relation to each other. They move across the sky in an orderly way. The North Star is always in the northern sky. Certain constellations appear in the sky at definite times of the year. The appearance of these constellations is very orderly. For this reason the stars were man's calendar for hundreds of years.

The Planets

Men of long ago noticed the order in the sky. They made star maps of the sky for the different times of the year. Night after night, men watched the sky and checked the maps. Some noticed that there were a few "stars" that did not move like the other stars. There were five "stars" that

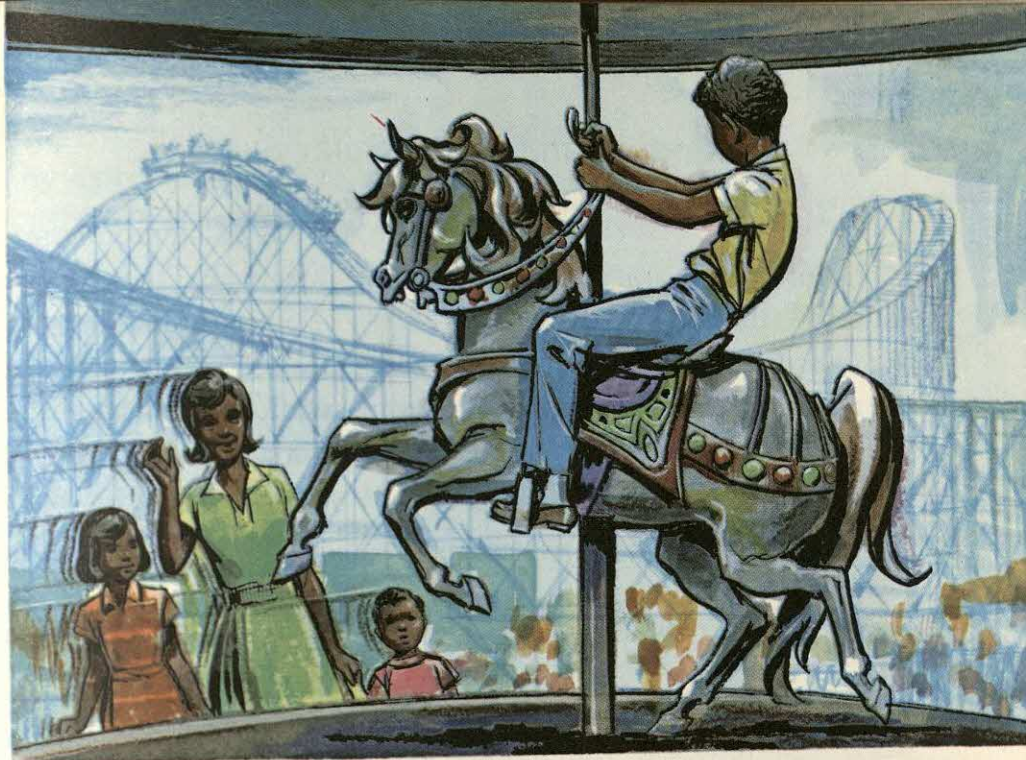
seemed to change their position among the other stars. These stars moved through the other star patterns. They wandered across the sky. In time these "stars" came to be called "planets," from the Greek word for "wandering."

Have you heard of the evening star or the morning star? They are very bright but they are not shown on the star map. They are not really stars. The evening and morning "stars" are planets. Mercury and Venus are evening or morning stars.

OBSERVE

Look for Mercury or Venus shortly before sunrise or shortly after sunset.

There are three other planets you can see—Mars, Jupiter, and Saturn. The planets, like the earth, do not have light of their own but reflect the light of the sun. See if you can find a planet in the sky. Watch how it moves across the sky. You will see planets in the same part of the sky that the sun seems to move through.



What Is Moving?

There is motion in the sky. The sun seems to move. The moon appears to move. The stars seem to move. What is moving? Are the heavenly bodies moving in their celestial sphere? Or is the earth moving?

It is not always easy to know what is moving. Have you ever been on a merry-go-round? As it starts up, you seem to stand still. The people watching you seem to move. Have you ever been on a

boat as it pulls away from the dock? What seems to be moving—the boat or the dock? Have you ever been on a train or a bus as another one passed yours? What seemed to be moving? Have you ever been on a plane and looked at the earth below? What seemed to be moving?

The sun and other heavenly bodies seem to move across the sky. Is the sun really moving, or is the earth turning? How have men answered this question?



Understanding the Solar System

Ancient Times

Let us go back to ancient times when Eratosthenes lived. This man was the Greek librarian and scientist who lived two hundred years before Christ. In those days, most people thought that the earth was the center of the universe.

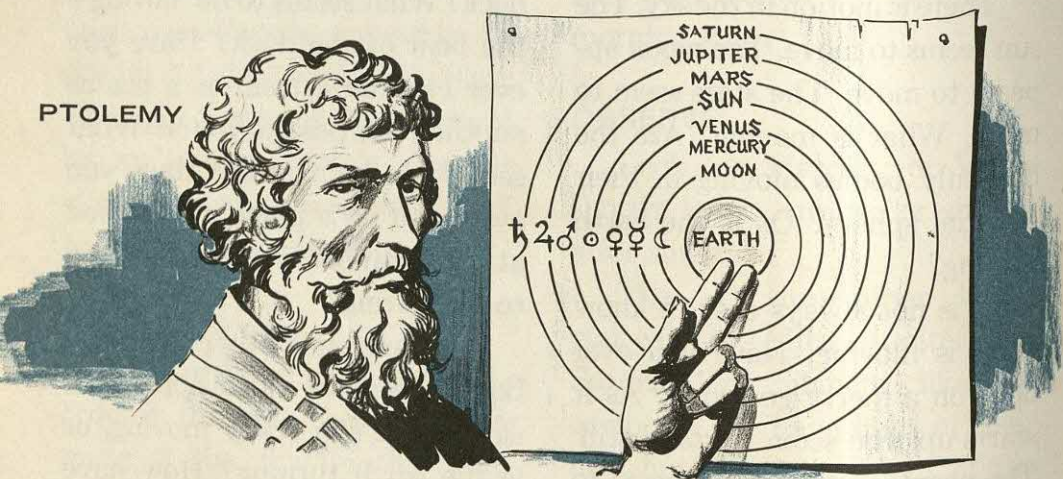
Make believe that you lived at that time. Suppose that one day you did the activity on page 229, when you observed the movements of the sun. There was very

the sun was going around and the earth was still. Then you would tell other people what you thought. Your guess would not be proven true, but it would explain for you, in some way, the motions that you saw. Your explanation would be like that of Ptolemy (TOL-e-mee), a Greek citizen who lived in the second century A.D.

Geocentric Theory

Ptolemy believed that the earth was the center of the uni-

PTOLEMY



little accurate knowledge of the motions of the earth and the sun in Eratosthenes' time. How would you explain the motions?

You would have to make a guess. You might decide that

verse. The sun, moon, stars, and planets moved around the earth, which did not move. This explanation is called the geocentric (jee-o-SEN-trik) or earth-centered theory.

Ptolemy studied the records kept by astronomers before him. He noticed that records showed the planets moving from west to east among the stars. But from time to time, one of the planets would seem to go backwards, from east to west. The planets always seemed brightest when they were halfway along this backward path.

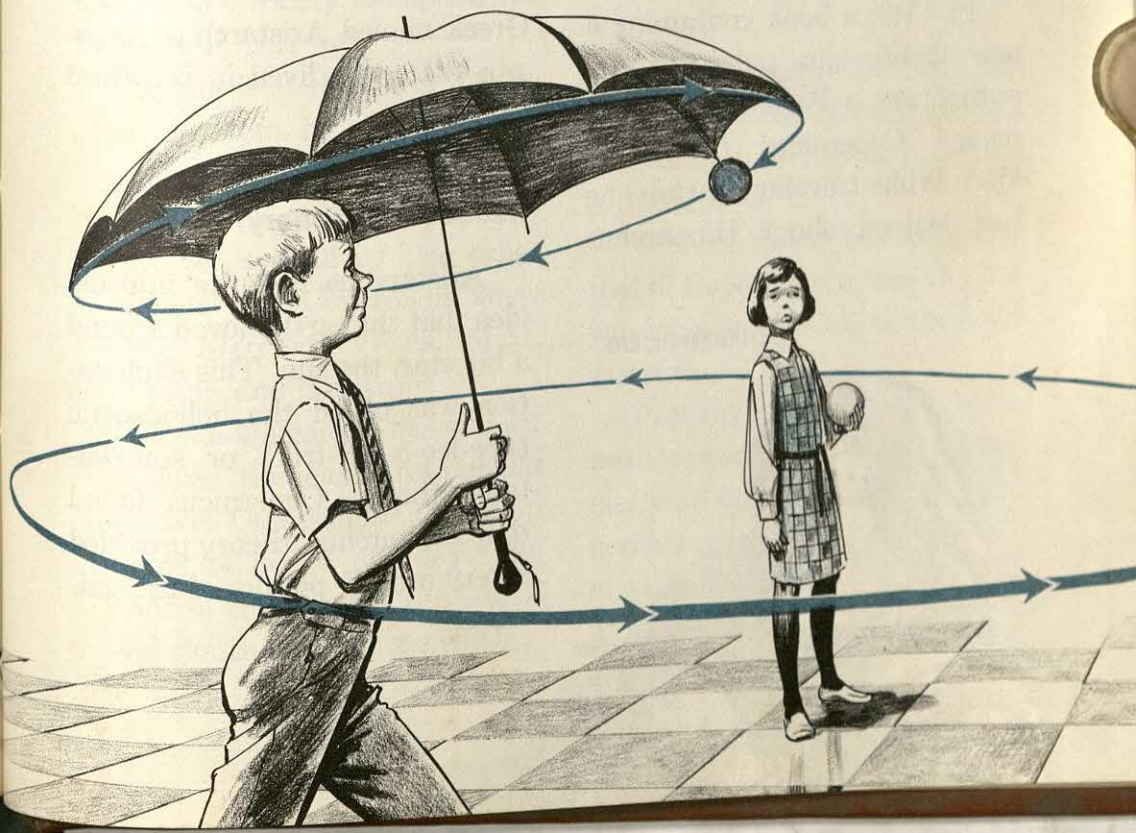
Many astronomers had tried to explain this irregular motion of the planets. Ptolemy did not agree with most of the explanations. The one that seemed most accurate to him was the theory of Hipparchus (hip-PAR-kus). Ptolemy based his own theory on it.

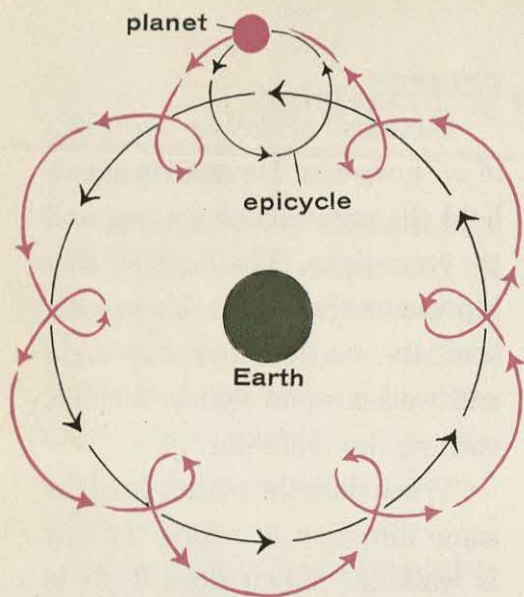
PREDICT

Put a ball of clay on one spoke of an umbrella. Have a classmate hold the umbrella above you and to your right. The ball of clay represents the planet. You represent the earth. Your classmate will walk around you in a circle, turning the umbrella.

When does the planet go in the same direction in which the boy is walking? When does it go in the opposite direction? If the ball of clay were a light, when would it seem brightest to you?

The path of the ball on the umbrella spoke represents the path that Ptolemy thought the





planet traveled. He called this path an epicycle (EP-i-sy-k'l). □□

Ptolemy's theory seemed to be a good one. It was accepted by astronomers for more than 1,000 years.

In 1543, a book containing a new theory was published. Its author was a Polish astronomer named Copernicus (ko-PER-ni-kus). While traveling in Italy, he had learned about Hipparchus

COPERNICUS



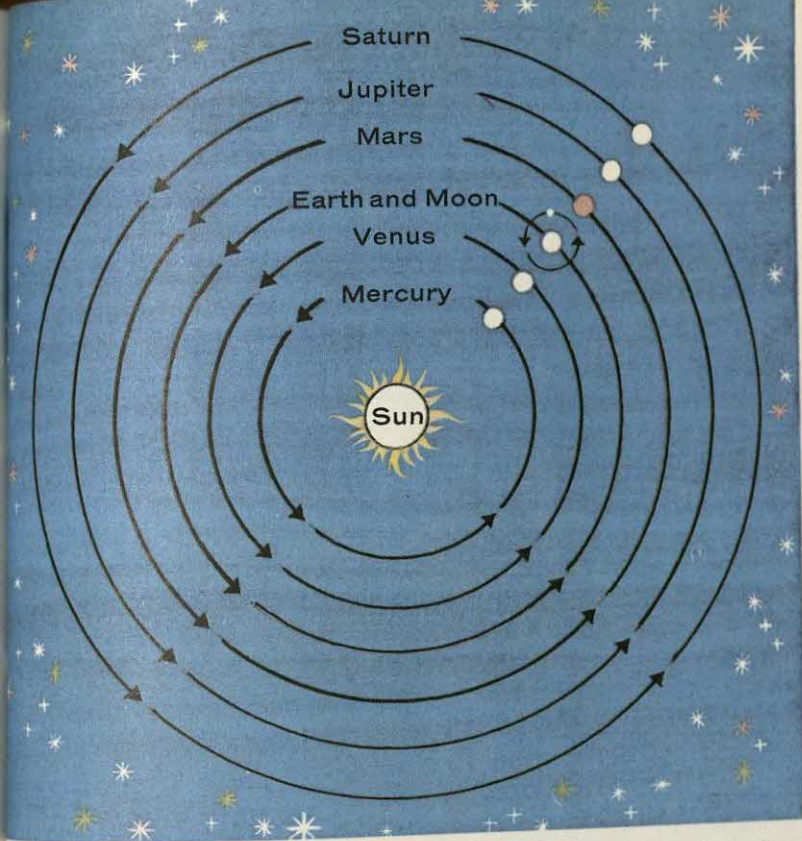
and Ptolemy, and had studied their theories.

Copernicus was a very good mathematics student, and he liked to figure things out in numbers. When he tried to use his mathematics on Ptolemy's theory, he was not satisfied. If the earth stood still, as Ptolemy said, the order in the universe was a very complicated one. Copernicus was sure there must be a much simpler explanation.

When Copernicus looked at the heavens, he saw just what Ptolemy saw, but he was not satisfied with Ptolemy's theory. He learned about another theory, even earlier than Hipparchus'. This theory was developed by a Greek named Aristarchus (ar-is-TAR-kus), who lived in the third century B.C.

Heliocentric Theory

Aristarchus had the unusual idea that the earth moved around a big star, the sun. This explanation was called the heliocentric (hee-lee-o-SEN-trik) or sun-centered theory. Copernicus found that Aristarchus' theory provided a very orderly picture of the universe.



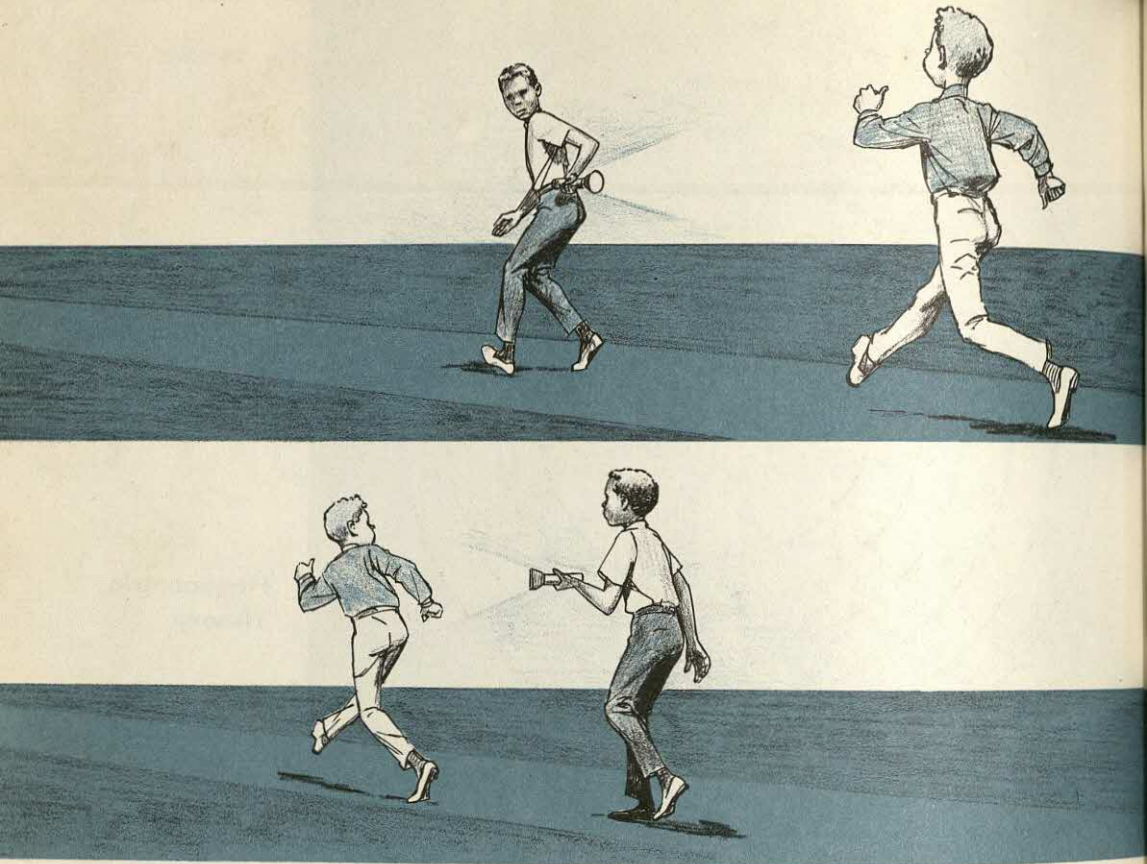
Heliocentric
Theory

Copernicus used Aristarchus' heliocentric theory to explain the universe in this way:

1. The sun is at the center of the solar system. Moving around it in circular paths are the planets. The earth is a planet. The moon revolves around it. The other planets that Copernicus knew were Mercury, Venus, Mars, Jupiter, and Saturn.
2. The sun appears to rise and set because the earth rotates on its axis. One complete rotation takes 24 hours, one day. The ends of the axis are the North and South Poles of the earth.
3. The North Pole of the earth points almost directly toward Polaris.
4. Seasons are caused by the earth's tilt on its axis, and the revolution of the earth around the sun.

Was the theory of Ptolemy or that of Copernicus nearer to what you have learned about the solar system?

Ptolemy explained the backward movement of the planets by means of epicycles. How did Copernicus explain the backward movement of the planets? Let us see.



OBSERVE

Do this activity with a friend. Have him stand about 15 feet in front of you, shining a flashlight at you. He will start to walk slowly away from you, keeping the flashlight pointed at you.

When your classmate starts walking, walk toward him very quickly. Keep your eyes on the flashlight. Pass him by and keep looking at the flashlight.

When did the light seem brightest? What seemed to happen to the light as you walked past it?

How might your observations help to explain the motion of a planet, such as Mars? How would Mars look to us if it traveled around the sun in the same length of time as Earth does?

Support for Copernicus' Theory

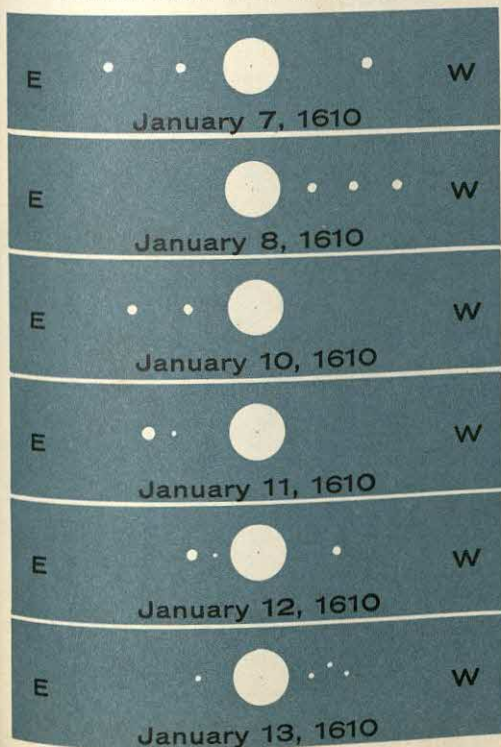
Some people did not agree with the theory of Copernicus because they could not feel the earth moving. Others were afraid to believe that the earth was a planet moving in space like other planets. They had been taught that all the heavenly bodies were perfect.

If the sun were the center of the solar system, then the earth would be part of what they called "the perfect heavens." But if this were so, then the earth would have to be perfect, too. People knew that the earth was not perfect, so many of them were afraid to believe this new theory. If only they could have some proof that what Copernicus said was true! Remember, Copernicus worked his theory out in numbers.

Finally, in the seventeenth century, something happened that supported the theory of Copernicus. The telescope was invented

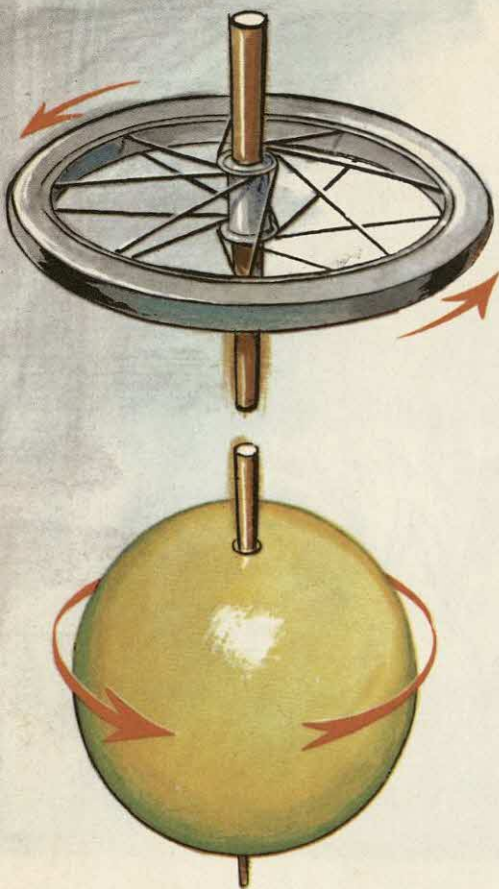


Jupiter and its moons as
Galileo saw and drew them



in Holland. Galileo (*gal-i-LAY-o*), who believed in Copernicus' theory, studied this telescope and made one for himself in 1609. He looked at the skies and saw many wonderful things.

Galileo found spots on the "perfect" sun and craters on the "perfect" moon. He also saw four of the moons of Jupiter. This proved that the earth was not the only body in space about which others revolved. How did Galileo's discoveries help the Copernican theory?



Rotation

If the earth is moving, as Copernicus taught, what are its motions?

If you put a stick through a wheel, the wheel can move around this stick. We call the stick an axis. The axis does not move, but the wheel is free to turn on it.

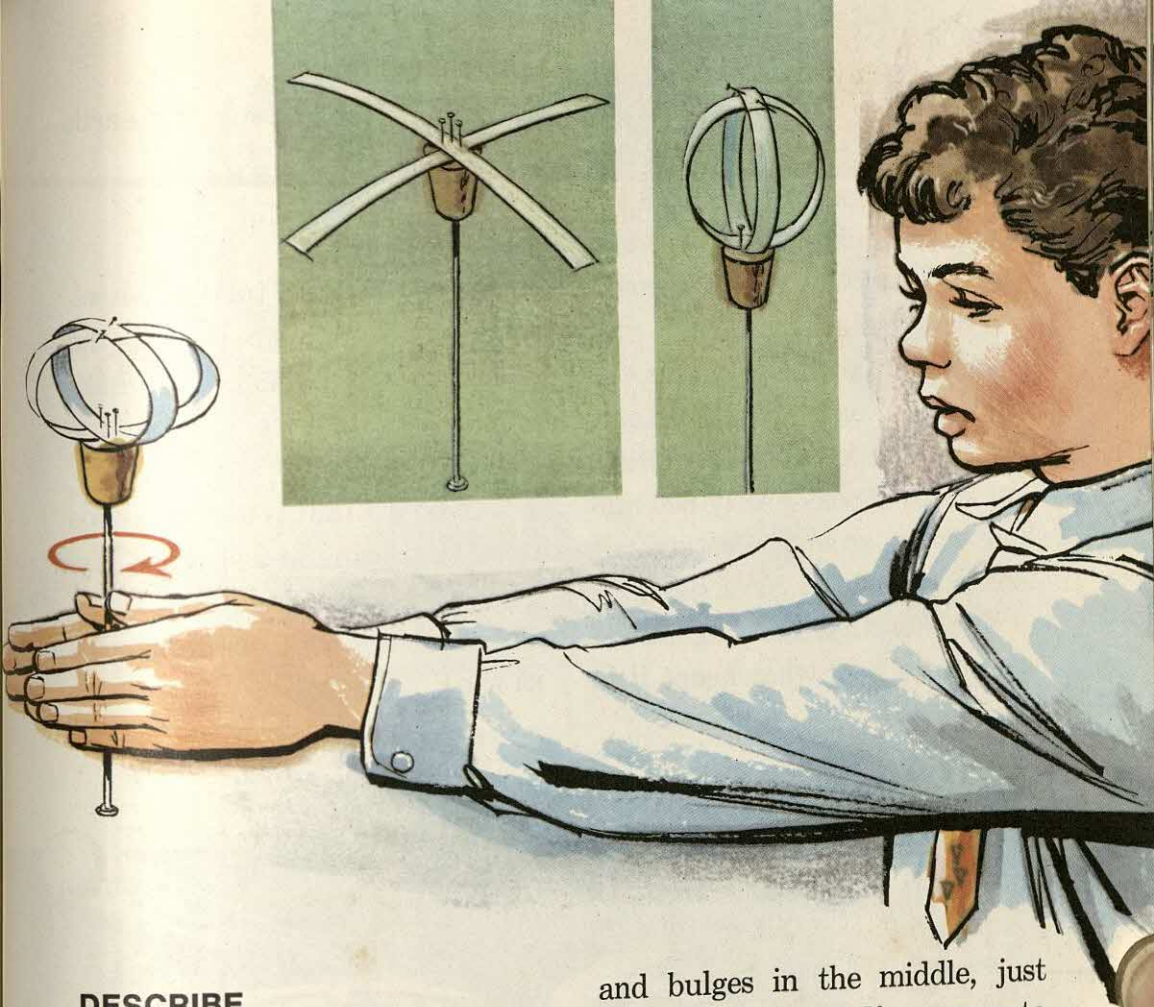
The earth does not have a stick through it, but it turns as if it had. We draw an imaginary line through the earth where the stick would be, and call it the axis of the earth.

One complete turn of the earth on its axis is called a rotation. Do all parts of the earth rotate at the same speed? Go back to the activity on page 232. Does the boy on the end or the one in the pivot spot move faster in order to get around the circle? Which part of the earth rotates the fastest?

At Nome, Alaska, the speed of rotation is 360 miles an hour. At New York and Chicago the speed of rotation is about 760 miles an hour. About how much faster is the earth traveling at Chicago and New York than at Nome?

Does the rotation of the earth have anything to do with the earth's shape?





DESCRIBE

Push a long knitting needle through a cork. Cut two strips of paper twelve inches long and one inch wide. Fasten the middle of each strip to the cork. Then bring the four ends together and pin them. Hold the needle in your hands and spin it very fast. What happens to the paper circles?

The change in shape that you can see is like what happens to the earth as it rotates. It flattens a little at the top and the bottom,

and bulges in the middle, just below the equator. If you were to measure the distance through the earth at the equator, you would find it to be 7,926 miles. The distance through the earth from pole to pole would be 7,899 miles.

Another effect of the earth's rotation is day and night. We measure time by the sun. A solar day is measured from the time on one day when the sun is highest in the sky, to the time on the next day when it is highest in the sky.

Revolution

Are there twelve hours of day and twelve hours of night all the time? When are days long and nights short? Why does the length of a day change?

Besides moving on its axis, the earth also travels around the sun. This motion is called revolution. The earth travels nearly 600 million miles around the sun. It makes the trip in $365\frac{1}{4}$ days.

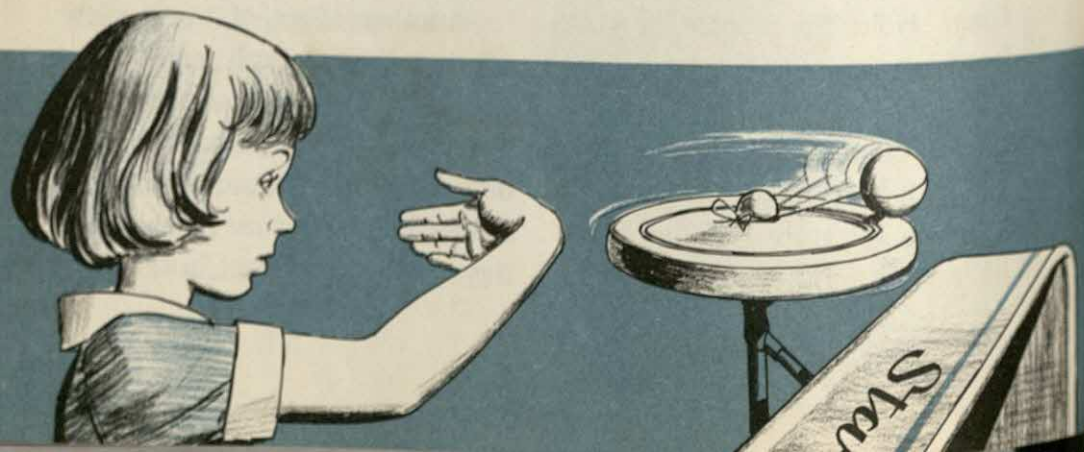
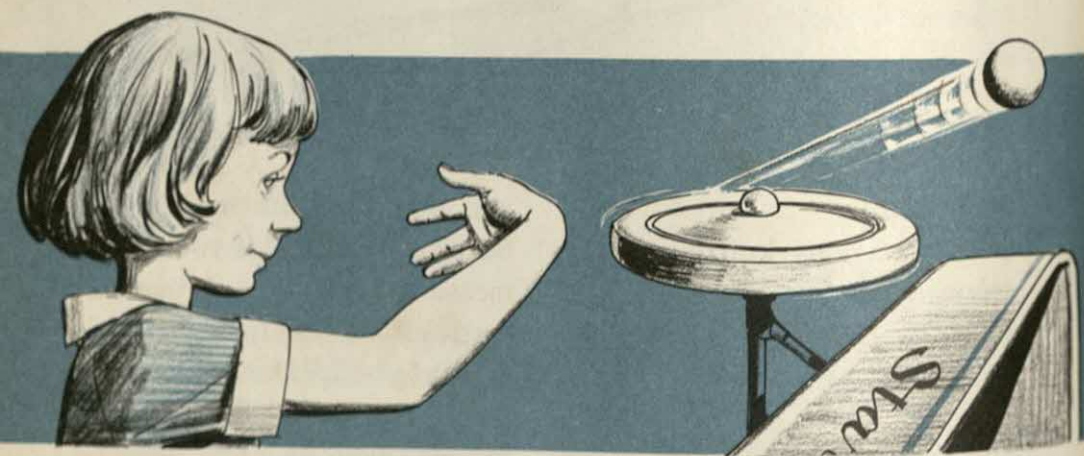
If the earth is traveling around the sun so fast, what keeps it in

its orbit? Why doesn't the earth fly off into space?

PREDICT

Arrange a freely turning wheel. Rest a ball on the rim of the wheel. Spin the wheel. What happens? Why doesn't the ball go around?

An object that is moving tends to go on moving in a straight line unless some outside force stops it. This tendency is called inertia (in-ER-sha).





Try the activity again, but this time tie a string to the ball. Fasten the end of the string to the center of the wheel. Put the ball on the rim, as before, and spin the wheel. What happens to the ball? The string acts against the inertia of the ball. □ □

Like the string, the sun's gravity acts against the inertia of the moving earth. A tug of war between gravity and inertia ends in a balance that keeps the moving earth in its orbit.

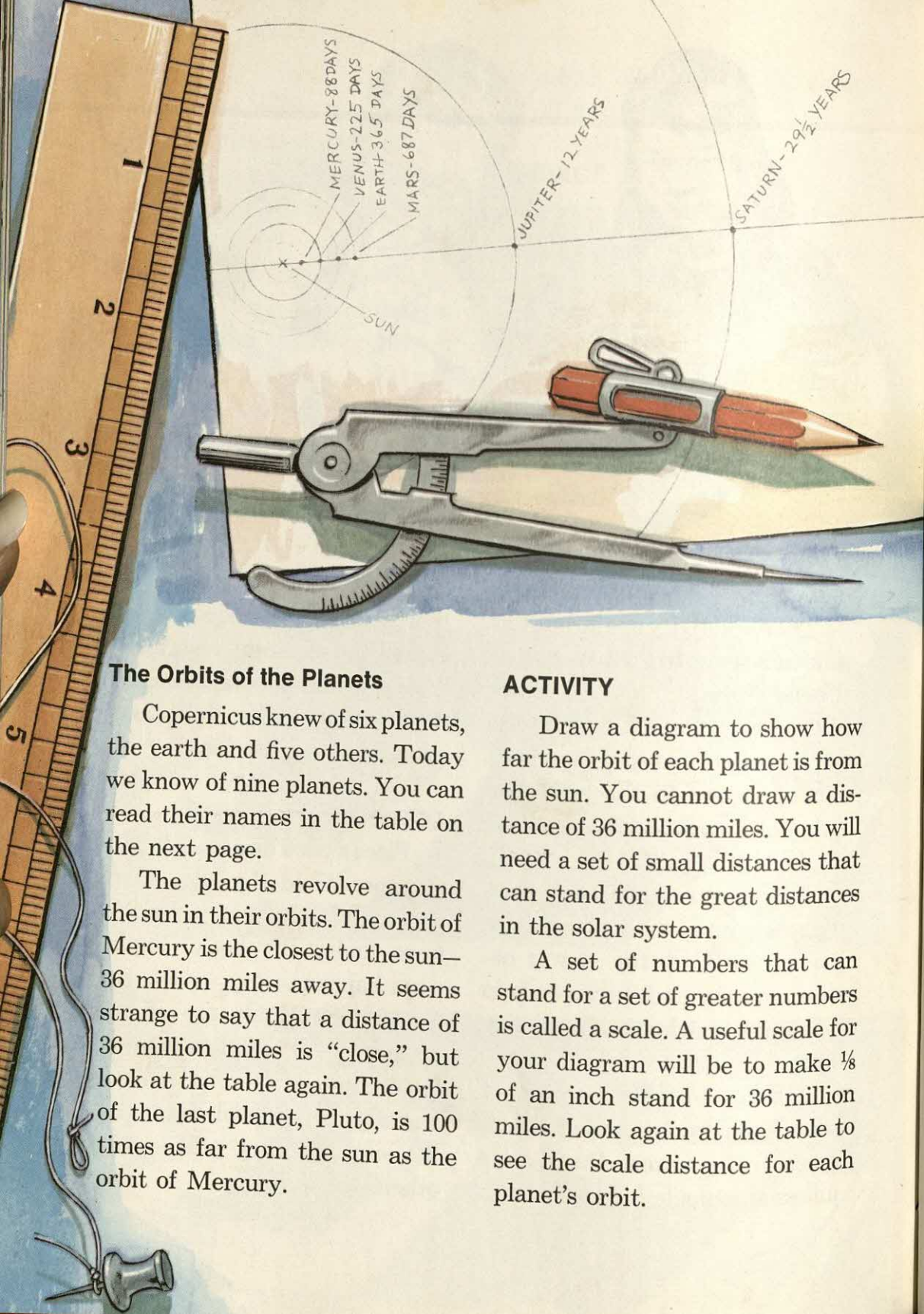
Inertia also affects objects at rest. When an object is at rest, it tends to stay at rest. It will do so unless an outside force acts on it.

Inertia is the tendency of a body at rest to remain at rest, and of a body in motion to remain in motion in a straight line, unless acted upon by an outside force.

ACTIVITY

Place a book on a smooth piece of paper. Hold the edge of the paper, and jerk the paper quickly from under the book. Explain what happens. □ □

All the planets are affected by inertia. All the planets are affected by gravity. The sun pulls on the planets. The planets pull on the sun, and they pull on each other.



The Orbits of the Planets

Copernicus knew of six planets, the earth and five others. Today we know of nine planets. You can read their names in the table on the next page.

The planets revolve around the sun in their orbits. The orbit of Mercury is the closest to the sun—36 million miles away. It seems strange to say that a distance of 36 million miles is “close,” but look at the table again. The orbit of the last planet, Pluto, is 100 times as far from the sun as the orbit of Mercury.

ACTIVITY

Draw a diagram to show how far the orbit of each planet is from the sun. You cannot draw a distance of 36 million miles. You will need a set of small distances that can stand for the great distances in the solar system.

A set of numbers that can stand for a set of greater numbers is called a scale. A useful scale for your diagram will be to make $\frac{1}{8}$ of an inch stand for 36 million miles. Look again at the table to see the scale distance for each planet's orbit.

URANUS - 84 YEARS

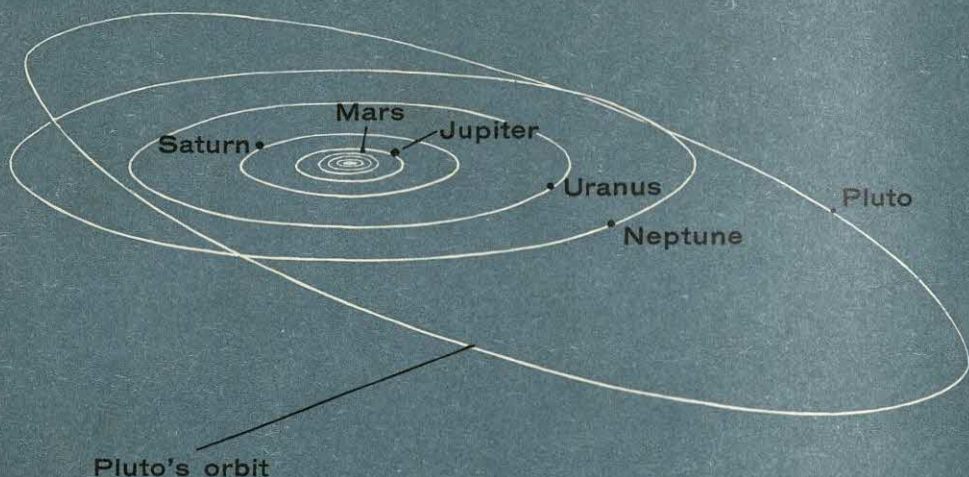
NEPTUNE - 165 YEARS



Planet	Distance from Sun (millions of miles)	Scale Distance (inches)	Length of Time for 1 Revolution
Mercury	36	$\frac{1}{8}$ inch	88 days
Venus	67	$\frac{1}{4}$ inch	225 days
Earth	93	$\frac{3}{8}$ inch	365 days
Mars	142	$\frac{1}{2}$ inch	687 days
Jupiter	483	$1\frac{5}{8}$ inches	12 years
Saturn	886	$3\frac{1}{8}$ inches	$29\frac{1}{2}$ years
Uranus	1783	$6\frac{1}{8}$ inches	84 years
Neptune	2794	$9\frac{3}{8}$ inches	165 years
Pluto	3670	$12\frac{3}{4}$ inches	248 years

Make your diagram on a sheet of paper that is 15 inches long. Hold the paper sideways, and draw a line across the center from left to right. Half an inch from the left-hand edge, make an X on the line to represent the sun.

With a ruler, measure $\frac{1}{8}$ of an inch from the X, and make a dot. Label the dot Mercury. Set the point of a drawing compass on the X, and set the pencil point on the dot. Draw a circle to represent Mercury's orbit. How long



does Mercury take to make one revolution in its orbit? Look at the table and put the number next to the name of the planet.

Do the same for each planet. When the circles that represent the orbits become too large to fit on the paper, draw only the part that does fit.

Your diagram is drawn on a flat surface. In space, Pluto's orbit is tipped, as the picture shows.

PREDICT

Here is another activity to help you understand the distances between the planets. This time, use a bigger scale and work

in the schoolyard, an open field, or a large gymnasium.

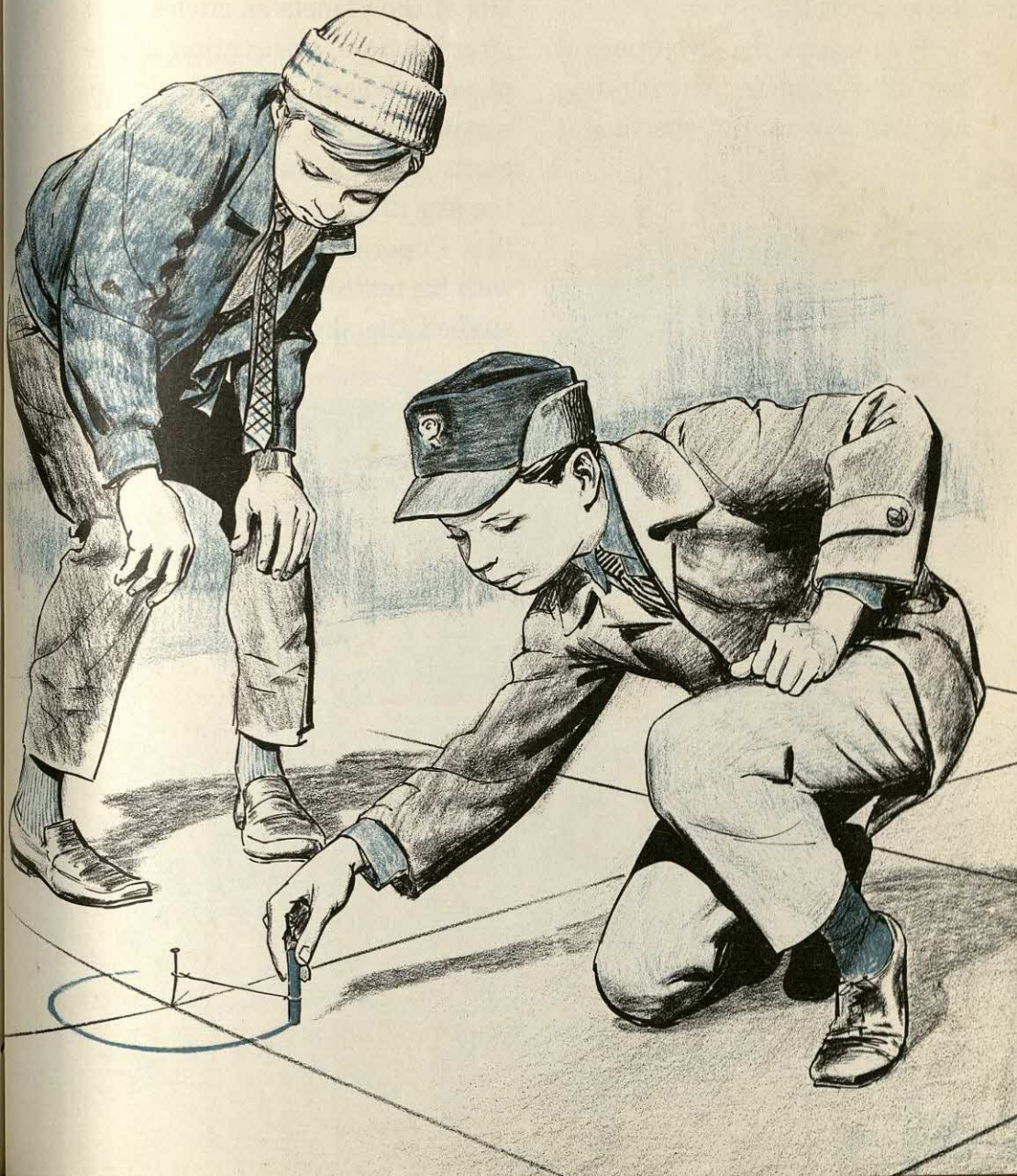
Pick out nine children, one for each planet. Let each child cut a piece of string to represent his planet's distance from the sun.

<i>Planet</i>	<i>Scale Distance</i>	
Mercury	4	inches
Venus	8	inches
Earth	1	foot
Mars	1½	feet
Jupiter	5	feet
Saturn	9½	feet
Uranus	19	feet
Neptune	30	feet
Pluto	40	feet

Choose a point in the center of the yard for the sun. Have someone stand there. Now measure off

four inches of string to represent Mercury's distance from the sun. Use chalk and the string to draw a circle around the sun. Have "Mercury" walk around the circle he has drawn.

Now each planet child can measure his distance and draw his orbit. Remember, one foot of string means 93 million miles. What do you think about the size of the solar system?



Have all the children line up, each on his own circle. At a signal, everyone start walking around his circle. Who completes his circle first? Who do you think will be last? □ □

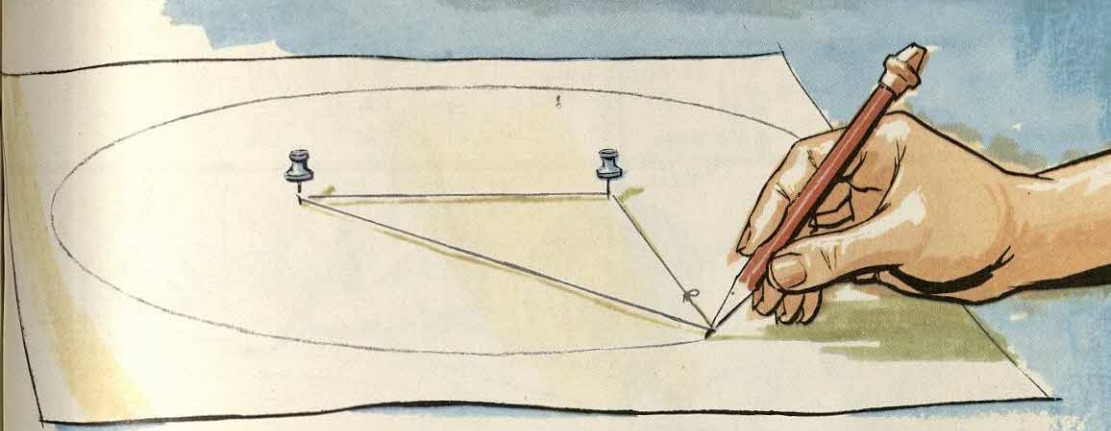
The time the earth takes to complete one revolution around the sun is called a year.

We measure the revolutions of the other planets in earth-days and earth-years. But the time it

takes a planet to complete a revolution is called a year for that planet. Measured in earth time, how long is a year on Mars? On Mercury? If you lived on Jupiter, how old would you be in Jupiter years?

Copernicus described the orbits of the planets as circles. But after his time, observation of the planets showed that his picture was not accurate. The paths of the earth and the other planets in the sky did not match the paths that Copernicus had worked out with his mathematics. Other men studied the sky. They measured





the position of the planets from the horizon or zenith. They drew more star maps which were more accurate. Finally, the correct path was figured out. What was it?

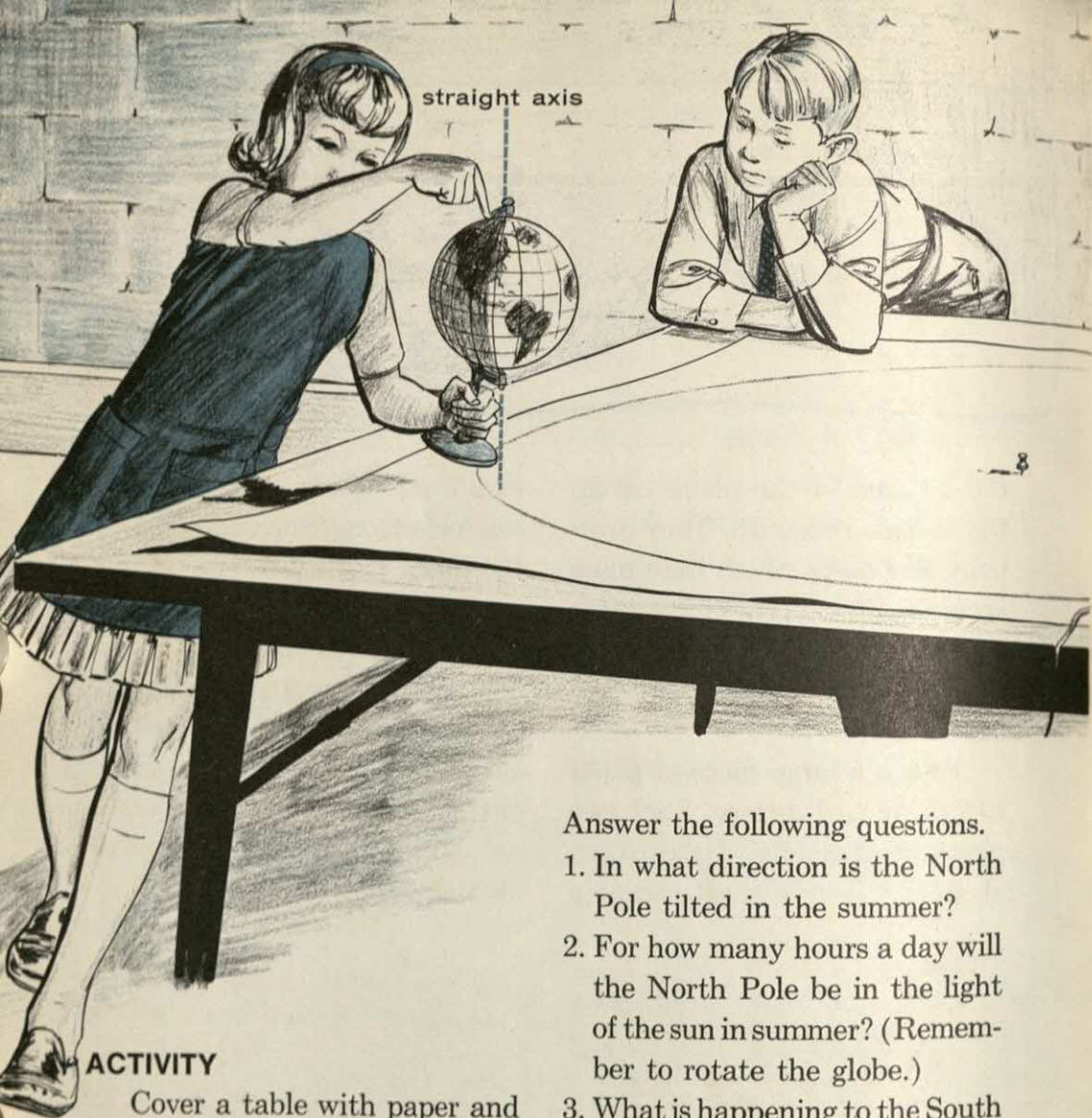
DISCOVER

Fasten a large piece of paper to a cardboard surface. Stick two pins in the middle of the paper, about six inches apart. Form a

loop from a piece of string eighteen inches long. Slip the loop over the pins.

Pull the loop tight with a pencil, and draw a line around the pins, keeping the string tight. The curve that you draw is called an ellipse (ee-LIPS). This is the shape of the path that the earth travels around the sun. It is the shape of all the planets' paths.





ACTIVITY

Cover a table with paper and use your pins and string to draw a large ellipse on it. Mark the position of one of the pins with an X. Place an unshaded electric light on the X. The light will represent the sun. Hold a globe on the ellipse, with the axis straight up and down. Rotate the globe and slowly move it around the ellipse.

Answer the following questions.

1. In what direction is the North Pole tilted in the summer?
2. For how many hours a day will the North Pole be in the light of the sun in summer? (Remember to rotate the globe.)
3. What is happening to the South Pole in the fall?
4. Does the same amount of light fall on North America as on South America in the fall?
5. In winter, which part of the earth is receiving most of the sun's light?
6. When are both poles in light at the same time?

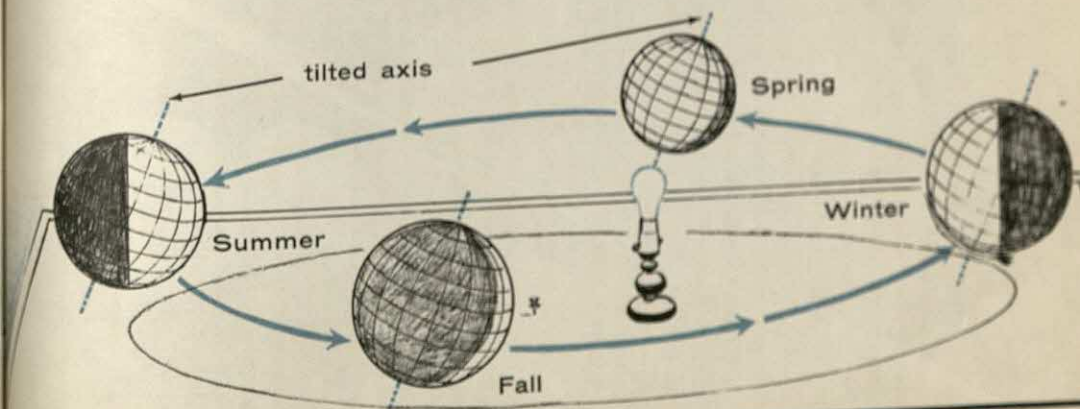


Discuss your answers. If the earth's axis pointed straight up and down, how many hours would day and night have all year round? Is this true?

So the earth must be tilted as it travels through space. Do the activity again, with the globe's axis pointing in many different

directions. Answer the questions again and discuss them.

Do the activity once more. This time, keep the axis pointed as it is in the picture at the bottom of the page. Answer the questions again. Which set of answers agrees with what you know about the earth and the sun?



The Sizes of the Planets

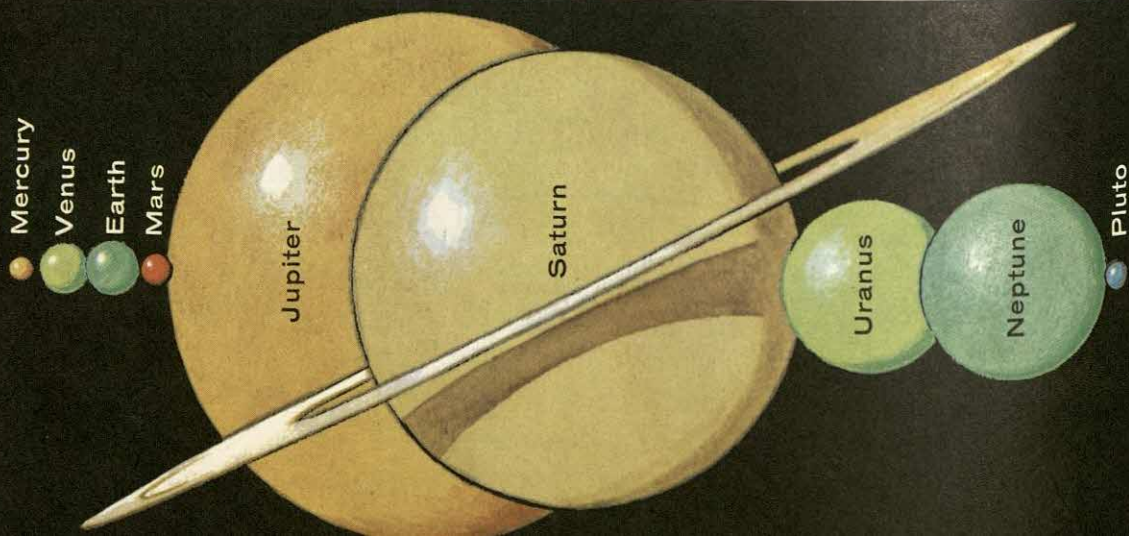
Your chart of the solar system showed only the distances between the sun and the planets. How do the planets compare in size? Clay models will help you to understand the sizes of the planets. Once again, you will need to use a scale. This time, $\frac{1}{4}$ of an inch will stand for 8,000 miles.

The longest distance through the center of a circle or sphere is called its diameter. The earth's diameter is about 8,000 miles long. The diameter of your earth model will be $\frac{1}{4}$ of an inch long.

Look at the table below. Make scale models of all the planets. Here is an easy way to measure the diameter of your scale models. Place two books on a table, with a ruler across them. Push the books together until the space between them is only as wide as the proper diameter for your model. When the clay ball just fits between the books, it is the right size.

How do your models of the planets compare in size? Using the same scale, a model of the sun would be 27 inches in diameter.

<i>Planet</i>	<i>Planet Diameter</i>	<i>Model Diameter</i>
Mercury	3,012 miles	less than $\frac{1}{8}$ inch
Venus	7,584 miles	less than $\frac{1}{4}$ inch
Earth	7,927 miles	$\frac{1}{4}$ inch
Mars	4,220 miles	more than $\frac{1}{8}$ inch
Jupiter	86,800 miles	$2\frac{3}{4}$ inches
Saturn	75,100 miles	$2\frac{1}{3}$ inches
Uranus	30,900 miles	$\frac{7}{8}$ inch
Neptune	33,000 miles	1 inch
Pluto	3,700 miles	$\frac{1}{8}$ inch





Light from the Sun

The sun is our star, a body so hot that it glows and gives off light. The sun gives light and heat to earth and the other planets.

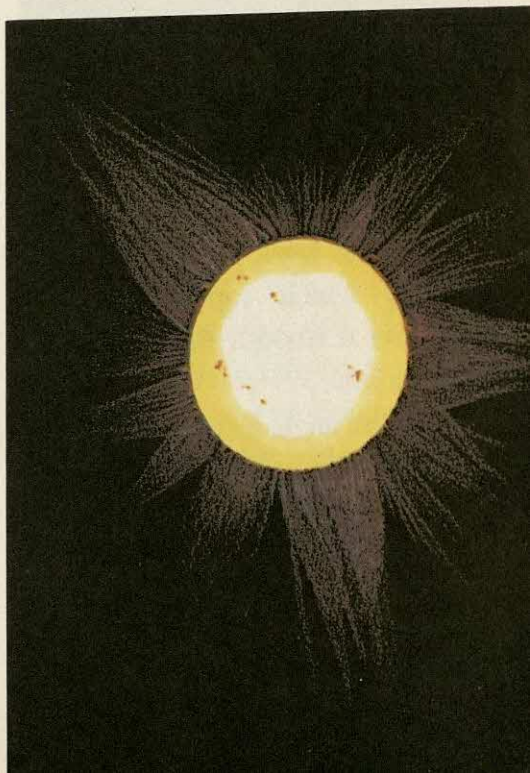
Distances in the solar system are very great, but light can travel vast distances in a short time. Light travels faster than anything else we know in the physical world. It travels 186,000 miles in a second. We say that 186,000 miles is a "light second."

The sun is our nearest star, and it is 93 million miles away. Light from the sun reaches our earth in a little more than eight minutes. We say that the sun is eight "light minutes" away.

Light from the next nearest star must travel for more than four years before it reaches the earth. We say that the star is more than four "light years" away.

A light year is the distance that light can travel in a year. We measure star distances in light years.

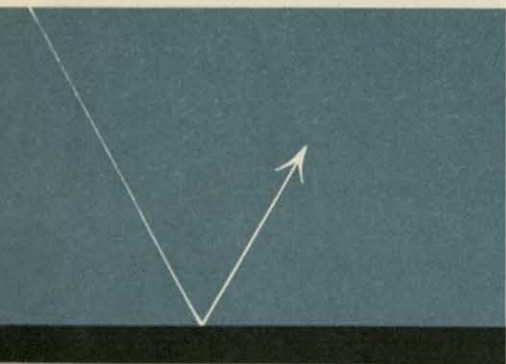
Light can travel through certain substances, but not through others. Substances that permit light to pass through are called transparent. Name some transparent substances. Substances that do not permit light to pass through are said to be opaque. The earth is opaque, and so are the other planets.



OBSERVE

What happens when light strikes an opaque object? Shine a flashlight against a corkboard. What do you observe? Shine a flashlight against a sheet of smooth white paper. What do you observe? Is there a difference? What causes it?

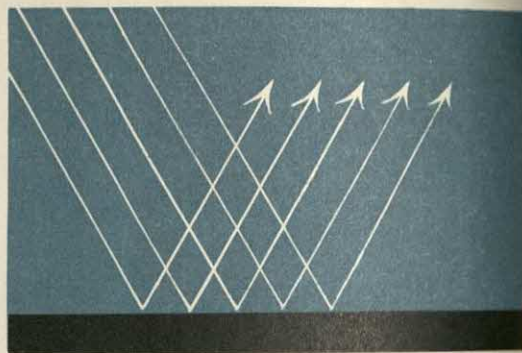
Observe what happens when you bounce a ball on a smooth flat surface. What happens when you bounce a ball on a bumpy surface? Light acts the same way.



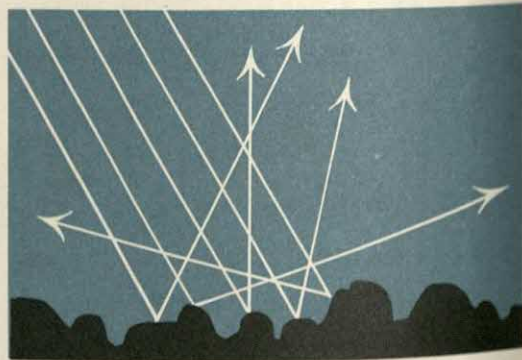
Light bounces back from a surface at the same angle at which it strikes. Look at the diagram above, which represents light striking a smooth flat surface at one point.

Is the angle at which the light hits the surface the same as the angle at which it bounces off? In what direction is the light reflected?

If we make a series of lines to represent light hitting a smooth flat surface at several points, the diagram will look like this.

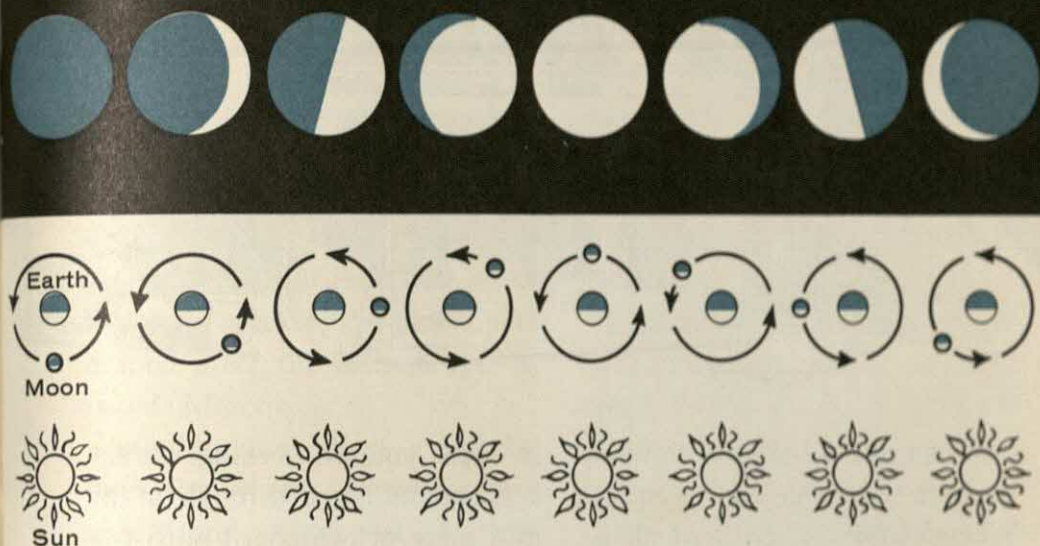


The lines with the arrowheads represent the reflected light. What would you say about the direction in which the light is reflected? Compare this diagram with the next one, which represents light striking a bumpy surface.



Are the angles at which the light hits the surface the same as the angles at which it bounces off? In what direction is the light reflected?

new moon crescent moon first quarter gibbous moon full moon gibbous moon last quarter crescent moon



The Moon Reflects Light

Why do we see the moon? Why does the moon seem to change its shape? Look at the diagram. How much of the moon is always lighted by the sun?

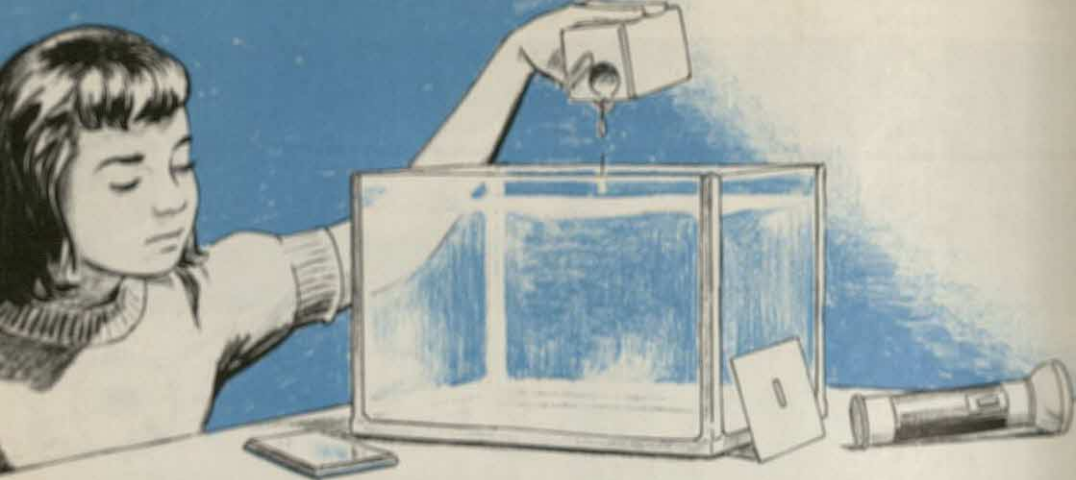
The part of the moon's lighted surface that we can see depends on where the moon is in reference to the sun, and in reference to us on earth. Look at the positions of sun, earth, and moon in each section of the diagram above. In each case, how much of the moon's surface is lighted by the sun? How much of the lighted surface can be seen from the earth?

The changing appearances of the moon during the month are

called phases (FAY-zeh). When the moon is between the earth and the sun, the unlighted half of the moon is toward the earth. We cannot see the moon then, and we call this phase the new moon. A day or two after this, we see a thin curved piece of the moon which we call a crescent (KRES-sent). Follow the phases of the moon.

Planets Reflect Light

The planets also shine by reflection. Sunlight falls on the surface of a planet and bounces off again. Some of the planets have phases like the moon. With a telescope you can observe the phases of Venus very clearly.



The orbit of Venus is between the sun and the earth's orbit. When Venus is at crescent phase it is nearest to the earth. When it is full it is farthest from the earth. When is it brightest? Why?

Much can be learned about the planets from the way light is reflected from their surfaces.

INVESTIGATE

Reflection of light is one way we can learn about the planets in space. What is another way?

Suppose there is water on the surface of a planet. Does water reflect light? Fill a fish tank with water, and add a few drops of milk. Shine a flashlight on the water. Is any light reflected from the water?

Place a mirror on the bottom of the tank and darken the room

in which you are working. Direct a flashlight beam through a slit in a piece of cardboard onto the mirror. What happens to the light when it hits the surface of the water? What happens as it hits the mirror? What happens as the beam comes out of the water?

All transparent substances do not allow light to go through them at the same speed. When light goes from one transparent substance into another, its speed is changed. This change in speed causes the light to bend. This bending of light is called refraction (ree-FRAK-shun). The amount of bending is different for different transparent materials.

Galileo used the knowledge of light refraction to make his telescopes. Refraction is another way to learn about the planets.

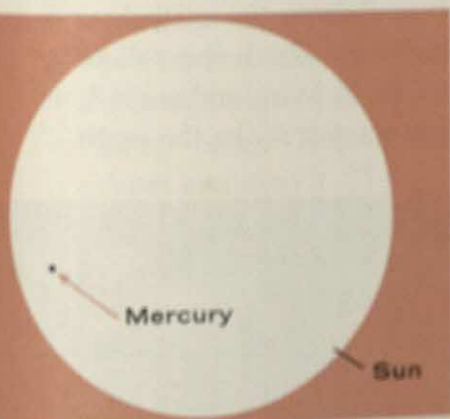
The Planets

Mercury

Your diagram of the orbits showed Mercury nearest to the sun. How long does it take Mercury to travel once around its orbit? Because it makes its revolution so quickly, the planet was named after the Roman god of speed, Mercury.

Is Mercury larger or smaller than the earth? Considering its size, would you expect Mercury to have much of a pull of gravity for objects on its surface? Why would you expect this for the planet Mercury?

Mercury is a very small planet.



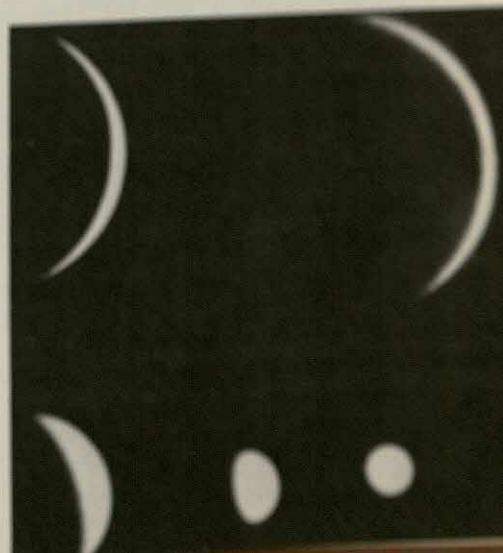
It is very near the sun. Would you expect the pull of gravitation between Mercury and the sun to be great or slight? Why?

Mercury always keeps the same side to the sun. Does this explain why the temperature on the sunlit side is hot enough to melt lead, and on the dark side it is about 450 degrees below zero?

Mercury has no atmosphere. Would you expect rain on Mercury? Could there be wind or clouds on Mercury? Would you expect to find human life on Mercury? List your reasons.

Venus

Just after sunset or just before sunrise, a bright and beautiful planet can often be seen low in the sky. This is Venus. Its beauty caused people to name it after the Roman goddess of beauty and love. The photograph below shows the phases of Venus.



The surface of Venus is covered by thick layers of clouds that reflect the sunlight. Space probes indicate that the clouds on Venus are not like the clouds we know on earth.

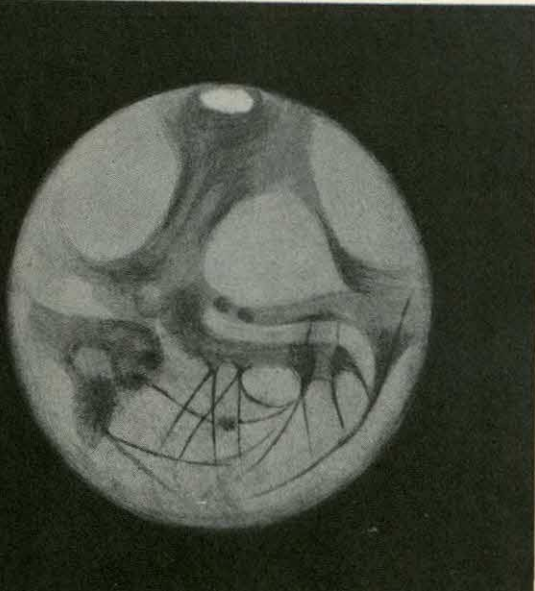
The clouds make it difficult for us to find out about the planet Venus. Although we know that Venus makes a revolution in 225 earth days, we do not know exactly how long it takes to make a rotation. It is thought that Venus makes a rotation in 225 days, also. If this were true, Venus would always have the same side turned to the sun. But because of its thick, cloudy atmosphere, Venus does not have a hot side and a cold side, as Mercury does. The space probes show that Venus has a surface temperature of about 800 degrees.

In 1962, the Mariner II rocket was shot toward Venus. It was designed to relay information back to the earth. Rockets and satellites help scientists learn more about the planets. Some of the information in this unit may change as scientists get more information.

Mars

You have probably heard more about Mars than about any other planet besides the earth. Because it appears reddish, Mars is named for the Roman god of war.

It is the second closest planet to the earth in distance. Let us see if it is close to the earth in any other way. Read the following facts about Mars, and see in how many ways it is like the earth.



1. Mars rotates once about every 24½ hours.
2. As it rotates, both sides have a chance to face the sun.
3. A year on Mars is about 670 Martian days, or 687 earth days.
4. Mars has a tilted axis.
5. Mars receives less than half as much heat and light as the earth.
6. Martian atmosphere has some water and carbon dioxide, but little oxygen.
7. There are no high mountains on Mars.
8. Mars has two moons.
9. There are no oceans on Mars.

Which of the facts you have just read might help to explain the following statements?

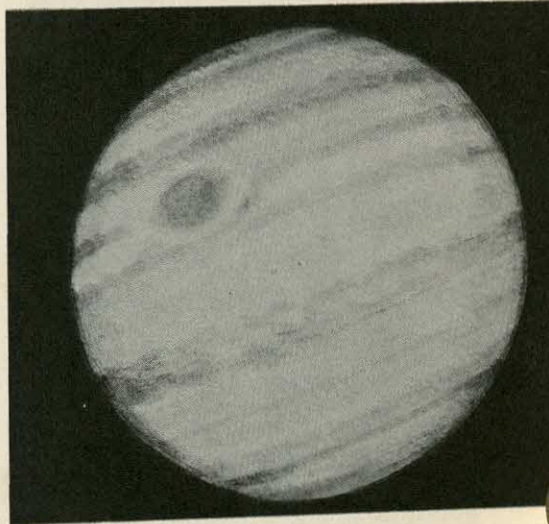
- a. The warmest day on Mars is like a mild winter day on earth.
- b. Plants, called lichens, make oxygen and store it. There may be lichens on Mars.
- c. From earth, no shadows can be seen on Mars.
- d. Mars has seasons.
- e. The temperature at some places on Mars gets as cold as the temperature of dry ice, about 120 degrees below zero.

If there is plant life on Mars, is it very much like ours?

Jupiter

Jupiter is the largest of the planets. The earth's diameter is about 8,000 miles long. Jupiter's is more than 86,000 miles long.

When Galileo observed Jupiter through his telescope, he saw four moons going around it. These are called "Galilean moons" in his



honor. You can see them through powerful binoculars. After Galileo's time, when more powerful telescopes were developed, eight more moons were discovered.

There is a large red spot, twice as wide as the earth, on the surface of Jupiter. This red spot can be observed to move across the face of the planet, indicating that Jupiter rotates. It rotates in less than ten hours.

Refer to your chart of the solar system to find Jupiter's distance from the sun. What would you predict about the temperature on Jupiter?

The gases on Jupiter are very poisonous; they are ammonia and methane. Because Jupiter has a very low temperature these gases are frozen. Jupiter receives very little light from the sun, yet it shines very brightly.

Saturn

Saturn is very far away from the sun, yet it reflects much light. A series of beautiful rings rotates around Saturn's equator. The rings can be seen only through a telescope. These rings are not solid. They are made up of many small particles clustered together.

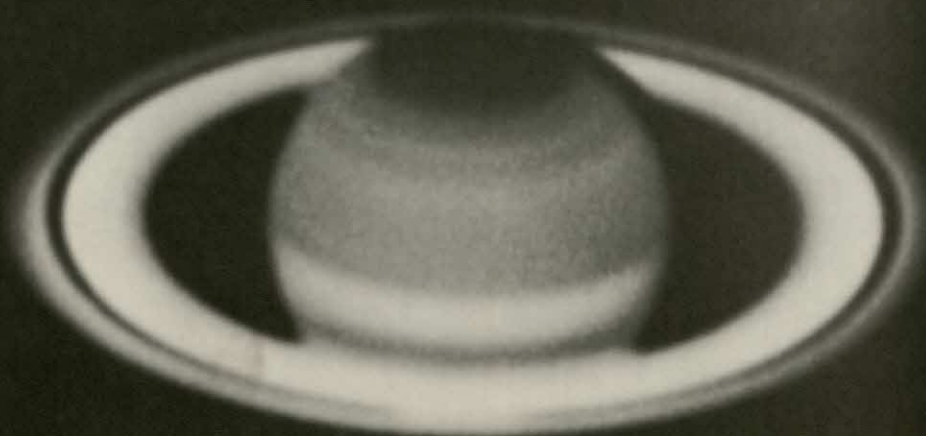
Besides its rings, Saturn has nine moons. Like Jupiter, Saturn

is very large and has an atmosphere of ammonia and methane. How would you expect the temperature of Saturn to compare with that of Jupiter?

Uranus and Neptune, the Twins

Uranus (yoo-ra-nus) was discovered in 1781. Astronomers plotted the orbit it followed. As time went on, they found that the planet did not follow a normal orbit. Uranus acted as if something was pulling it out of its orbit. Might there be another planet beyond Uranus?

Two men began the search for the unknown planet about the same time. Adams, in England, was the first to figure out where the new planet ought to be, but he could not persuade astronomers to look for it. Two years later, in 1846, a Frenchman named Lever-





URBAIN LEVERRIER



PERCIVAL LOWELL

rier finished his calculations. Leverrier had a German friend with a powerful telescope. The German, Galle, looked where Leverrier told him, and found the new planet in less than an hour. The planet was named Neptune.

Uranus and Neptune are about the same size, and both have moons—five for Uranus and two for Neptune. Why do you think that both planets would be cold and dark? Uranus and Neptune have the same kind of atmosphere as Jupiter and Saturn.

Pluto

Even the discovery of Neptune did not completely explain the motion of Uranus. Could there be

a ninth planet? Percival Lowell, an American astronomer, thought so. He started looking for another planet in 1905, but he had not yet found it when he died in 1916.

In 1930, the planet was found at last by another American, Clyde Tombaugh. He named the planet Pluto for two reasons. Pluto was the name of the god of darkness, a good name for the farthest planet from the sun. And the name Pluto begins with the initials of Percival Lowell, who began the search for the ninth planet.

With the planet Pluto, we reach the outer edge of the solar system as we know it today. Pluto is a twentieth-century planet.

Other Members of the Solar System

The Minor Bodies

The planets are not the only bodies that revolve around the sun. Within this magnificent solar

system, scientists know of three other kinds of bodies. They are the meteors, the comets, and the asteroids.



Meteors

Sometimes you can notice a sudden bright streak in the sky. You may have called it a shooting star. Such bright streaks are called meteors. They are made by particles that range in size from specks of dust to great chunks of rock or iron. The particles are called meteorites.

As meteorites come near the earth's orbit, the gravity of the earth pulls them toward it. When they enter the atmosphere, they begin to glow red hot. Meteors are visible only for a few seconds.

Most meteorites burn up in the atmosphere, but some fall to earth. A very large meteorite can strike with such force that it dents the earth. In Arizona, there is a crater nearly a mile wide, dug by a meteorite that fell about 700 years ago.

Look at the time exposure to the left. Which streaks were made by stars? Which were made by meteors?

Comets

Perhaps the most amazing sight you may ever see in the sky is a comet, a bright object with a cloudlike tail of glowing matter. Unlike meteors, comets are seen outside the earth's atmosphere, shining like planets in the reflected light of the sun.

A comet may remain visible in the sky for days or weeks. Each comet follows an orbit around the sun. The orbits of some comets are so large that the comet may be visible from the earth only once in 400 years or more.

One of the most famous and spectacular of the comets is Halley's Comet. It was named after an English astronomer, Edmund Halley, who studied its orbit when it appeared in 1682. He was able to prove that this was the same comet that had appeared on several other occasions, and he correctly predicted its return in 1758.

Halley's Comet appears about every 75 years. Its next predicted return is in 1986.



Asteroids

Look at the large space on your distance chart between Mars and Jupiter. An Italian astronomer named Piazzi thought that there might be another planet in this space. When he examined it, he discovered a small moving body which he named Ceres (SEE-reez). Ceres follows an orbit around the sun and reflects the sun's light.

Many more bodies like Ceres have been found in the space between Mars and Jupiter. We call them asteroids because they look like stars, or planetoids because they are really very small planets. Ceres is the largest asteroid, and its diameter is only 480 miles. Why is 480 miles considered small?

Each of the asteroids revolves around the sun in its own orbit and at its own speed.

What have you learned about the bodies that revolve around the sun? What is the shape of the earth? What are some ways you

can know about the shape of the earth? Does a compass point to the North Star? What does it point to? Can you see motion in the sky? What is moving? What is the shape of a planet's path around the sun? How is the earth like the other planets? What makes the earth very different from the other planets?

Many thousands of years of learning have made it possible for us to know this much about our solar system. Now men have invented ways to leave the surface of our planet. Soon we will be exploring some of the other members of the solar system.

Explorers who land on the moon or on another planet will need pressure suits, supplies of oxygen and special foods, and many scientific instruments. But their most important equipment will still be their eyes and hands and minds, the same equipment men have always used to study the world around them.



THINK

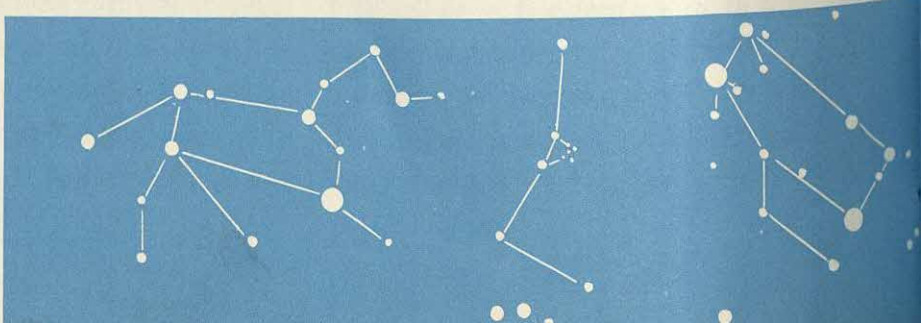
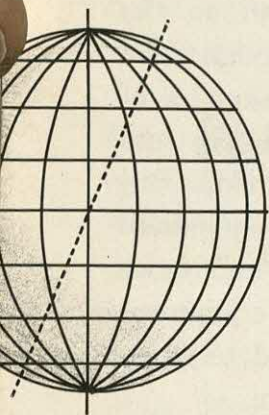
If we were on lunar time instead of solar time, how would our calendar be different and our time intervals be different?

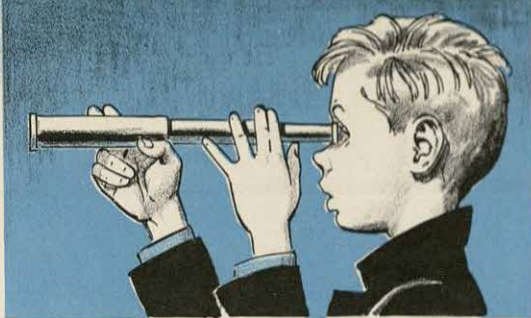
What reasons can you give to disprove that the earth is in the center of the universe and that the sun and planets rotate around it?

If the earth's axis was straight up and down, what effect would it have on our seasons?

Think about what kinds of living things that might be on each of the planets. Give reasons for or against the kind of life that we know.

Explain why an eclipse does not occur during every full and new moon.





PROJECTS

Construct scale models of the solar system: (1) by the sizes of the planets; (2) by the distances between the planets.

Visit a planetarium or observatory. Observe a Foucault pendulum.

Write an autobiography for one of these men who contributed some knowledge to the study of astronomy: Galileo, Copernicus, Kepler, Newton.

Observe the moon with a pair of binoculars or small telescope. Construct a clay or plaster model of the moon's surface.

After reading some myths and legends about the stars and planets, observe the night sky and report on how some of the stories could have started from night observation.

Observe the night sky and find one or more constellations besides the Big Dipper that can be used to tell time. Give reasons why certain constellations can be used.

The movements of planets and stars have given us our sense of time. Find out what you can about the development of calendars and of different time-telling instruments. From your observations, make your own calendar or time-telling instrument.



GLOSSARY

abdominal cavity (ab-DOM-uh-nul KAV-uh-ti). * Body area containing the stomach, large intestine, and small intestine.

accessory organs (ak-SEHS-uh-rih AWR-gunz). Those organs which aid any system of organs.

acid (AS-id). Sour substance such as vinegar.

algae (AL-gee). Tiny, microscopic plant life found in water.

alimentary canal (al-i-MEN-ta-ree kuh-NAL). Passageway through which food travels through the body.

alkalis (AL-kuh-lyz). Substances present in some foods.

altitude (AL - tuh - tood). Height above the earth's surface.

alveoli (al-VEE-oh-ly). Tiny, microscopic air sacs which are divisions of the bronchi.

ammonia (uh-MOHN-yuh). Poisonous gas present on Jupiter.

anemic (uh-NEE-mik). Lacking in enough red blood cells.

aorta (ay-OR-ta). Large artery from the heart.

aphids (AY-fids). Insects that milk the sap from plants.

appendix (uh-PEN-diks). Narrow tube attached to the end of the large intestine.

aquarium (uh - KWAIR - i - uhm). Tank for fish and water plants.

Aristarchus (ar-is-TAR-kus). Greek astronomer of the third century B.C.

armadillo (ahr - muh - DYL - oh).

Small, burrowing animal whose head and body have a hard, bony covering.

artery (AHR-tuh-ri). Tube that carries blood from the heart to other parts of the body.

asteroid (AS-tuh-roid). Small, heavenly body revolving about the sun, mostly between the orbits of Mars and Jupiter.

astronomer (uh-STRAHN-uh-mur). Person who makes a scientific study of the sun, moon, planets, and stars.

astronaut (AS-truh-nawt). Traveler in outer space.

athlete's foot (ATH-leets FOOT). A disease caused by fungi which affects the skin between the toes.

atmosphere (AT-muhs-fir). The air surrounding the earth.

auricles (OH-ri-k'lz). The upper chambers of the heart.

axis (AK-sis). Imaginary line that runs through the center of the earth between the North and South poles.

balanced diet (BAL-uhns'd). Food containing the necessary vitamins and minerals.

biceps (BY-seps). Muscle on the front of the upper arm.

bile (BYL). Fluid manufactured by the liver.

bile duct (BYL DUKT). Small tube going from the liver to the gall bladder.

biologist (bi-AHL-uh-just). Person

**To aid in pronunciation all primary stress syllables have been put in capital letters and the secondary stress syllables are in italics.*

studying plant and animal life.
bladder (BLAD-uhr). Part of the urinary system that collects the liquid waste material.

blood plasma (bluhd PLAZ-muh). The liquid part of the blood.

body structure (BOD-i STRUK-chur). Arrangement of the physical parts of your body.

bone (BOHN). The hard, white material that makes up the skeleton.

bowel (BOW-uhl). Common name for the large intestine.

bronchi (BRONG-ky). Tubes from the trachea to the lungs.

burrow (BUHR-oh). Hole in the ground dug by an animal.

cactus (KAK-tuhs). Leafless, desert plant with sharp spines.

calcium (KAL-si-uhm). Essential mineral found in milk foods.

calorie (KAL-uh-ri). Measure of the amount of heat given off by the body.

capillary (KAP-uh-lehr-i). Very small blood vessel in the body.

carbohydrates (car-bo-HI-drayts). Foods containing starches or sugar.

carbon (KAHR-bun). Element found in carbohydrates.

carbon dioxide (KAHR-bun dy-OK-syd). Gas given off when we exhale.

cartilage (KAR-ti-lij). Rubbery tissue over skeleton.

Cassiopeia (kas-ee-oh-PEEYUH). Constellation in the form of a W.

cavern (KAV-urn). Large underground cave.

cavity (KAV-uh-ti). Hole in a tooth

caused by decay due to bacteria.
cell (SEL). Smallest unit of living matter.

Cepheus (SEE-foos). Constellation shaped like a small house.

Ceres (SEE-reez). Small asteroid moving around the sun.

chameleon (kuh-MEE-li-uhn). Lizard that can change the color of its skin to blend with its surroundings.

chemical change (KEM-uh-kul CHAYNJ). The forming of new substances with new properties.

chlorine (KLaw-reen). Element found in table salt.

chyme (KYM). Thick liquid in the stomach.

circulatory system (SUHR-kyoo-luh-tawr-i sis-tum). The flow of blood throughout the body.

citrus fruit (SIT-rus FROOT). Raw fruit such as oranges, lemons, and grapefruit.

clavicle (KLAV-i-kuhl). Another name for the collarbone.

climate (KLY-miht). The weather conditions of a place over a period of time.

comet (KOM-it). Heavenly body moving about the sun in a long, oval orbit; it usually has a bright center and a long, shining tail.

compound (KOM-pound). Substance formed by chemical combination of two or more elements.

concept (KON-sept). Idea which helps a scientist understand another idea.

conservation (kon-suhr-VAY-shun). Careful use and protection of natural resources.

constellation (*kon-stuh-LAY-shun*). Groups of stars that form an imaginary picture in the sky.

constipation (*kahn-stuh-PAY-shun*). Difficulty in getting rid of solid waste material from the body.

continental glaciers (*kahn-tuh-NEN-tuhl GLAY-shurz*). Great ice sheets that still cover much of Greenland and Antarctica.

Copernicus (*ko-PER-ni-kus*). Polish astronomer who developed theory that all planets revolve around the sun.

cosmonaut (*KAHZ-muh-naht*). Traveler in space.

coyote (*KY-oh*t). North American desert animal.

cranium (*KRAY-nee-um*). Bony covering that protects the brain.

crater (*KRAY-tuhr*). Mouth or opening of a volcano.

crescent (*KRES-sent*). Thin, curved portion of the moon.

crown (*KROWN*). The top part of a tooth.

decay (*dih-KAY*). Gradual rotting away of tissue.

deficiency diseases (*deh-FISH-un-see*). Those caused by lack of vitamins and proper food.

dehydration (*dee-hi-DRAY-shun*). Extreme loss of water from the body or a substance.

delta (*DEL-tuh*). Area formed at the mouth of a river from deposited earth and sand.

dentin (*DEN-tin*). Bone-like material under the enamel of a tooth.

dermis (*DUR-mus*). Skin layer be-

low the outermost skin layer.

desert (*DEZ-urt*). Sandy region with little rainfall.

diaphragm (*DY-a-fram*). The muscles which control breathing.

digestion (*di-JEHS-chun*). Process by which body changes food to form in which it can be used.

dinosaur (*DY-nuh-sawr*). Type of giant reptile that lived millions of years ago.

dispersal (*dis-PER-sal*). Accidental migration.

dome mountain (*DOHM MOUN-tuhn*). Formed when magma pushes up the rock layers of the earth's crust.

domestic animal (*duh-MES-tik*). Living under the care of man.

dormancy (*DOHR-mun-see*). Inactive period for a plant or animal.

drift (*DRIFT*). Earth materials deposited by a glacier.

drought (*DROWT*). Long period of time without rainfall.

duct (*DUKT*). Tiny tube from an organ of the body.

dune (*DOON*). Soft hills of sand found on a desert.

eclipse (*ih-KLIPS*). A complete or partial darkening of the sun when the moon comes between it and the earth (solar eclipse); a complete or partial darkening of the moon by the earth's shadow (lunar eclipse).

element (*EHL-uh-munt*). Substance which cannot be broken down into other substances by chemical means.

ellipse (*ee-LIPS*). Path that earth

and planets travel around sun.
enamel (ee-NAM-uhl). Outer hard layer of a tooth.

epicycle (EP-i-sy-k'l). Path traveled by planets.

epidermis (ep-uh-DUR-mus). The outer layer of the skin.

Eratosthenes (er-a-TOS-the-neeZ). Greek scientist who used shadows to find out about the shape of the earth.

erosion (i-ROH-zhun). Gradual wearing away of rocks by running water or wind.

esophagus (ee-SOF-a-gus). Long muscular tube leading from the mouth to the stomach.

estivation (ess-tuh-VAY-shun). Inactivity of animals during the summer.

excretory system (EK-skruh-tohr-ee SIS-tum). The organs of the body that rid it of solid and liquid waste materials.

exhale (eks-HAYL). Breathing out carbon dioxide.

expand (eks-PAND). To increase in size.

fault (FAWLT). Break in a rock surface which causes the rock to change position.

femur (FEE-mur). Bone extending from the hip to the knee.

fibula (FIB-yuh-luh). Bone of the lower leg; calf bone.

fixed star (FIKST STAHR). Star whose position does not change.

food chain (FOOD CHAYN). Food relationships between plants and animals.

food web (FOOD WEBB). Another

name for food cycles in nature.

Galileo (gal-i-LAY-o). Seventeenth century scientist who made many discoveries in the field of astronomy.

gall bladder (gawl BLAD-uhr). Sac which stores bile produced by the liver.

geocentric (jee-o-SEN-trik). Based on the theory that the earth is the center of the universe.

geographic North Pole (jee-uh-GRAF-ik NAWRTH POHL). The actual location of the North Pole in the arctic region.

geologist (ji-AHL-uh-jist). Person trained in the study of features of the earth's surface.

gills (GILZ). Part of the body of a fish used for breathing underwater.

glacier (GLAY-shur). Large mass of ice formed from snow in high old mountains.

gland (GLAND). Organ which produces special substances in the body such as saliva or digestive chemicals.

goiter (GOI-tur). Swelling caused by disease of the thyroid gland.

granite (GRAN-iht). Rock formed from materials exposed to extreme heat.

gravity (GRAV-uh-ti). Pull of the earth that draws all objects on or near the earth towards its center.

grub (GRUHB). Fat, worm-like animal which is a stage in insect growth.

habitats (HAB-i-tats). The places

in which animals and plants live.
heartbeat (HART-beet). Muscular action of the heart that pumps blood throughout the body.

heliocentric (hee-lee-o-SEN-trik). Based on the theory first developed by Aristarchus that the sun is the center of the universe.

hemisphere (HEM-i-sfeer). Half of a sphere or half of the earth.

heredity (he-RED-i-tee). Passing on of traits from parents to children.

hibernation (hy-ber-NAY-shun). Inactivity of animals during winter months.

Hipparchus (hip-PAR-kus). Greek scientist who developed theory of the irregular motion of planets.

horizon (ho-RY-z'n). Place where the earth and sky meet.

hydrochloric acid (HY-druh-klohr-ik AS-id). Substance produced by stomach glands to aid digestion of food.

hydrogen (HY-druh-jun). Element that is a lighter-than-air gas.

humerus (HYOOM-uh-rus). Long bone that extends from the elbow to the shoulder.

igneous rock (IG-ni-uhs ROK). The rock formed from materials exposed to extreme heat.

inertia (in-ER-sha). Tendency of an object to remain in motion until stopped by an outside force.

inhale (in-HAYL). Breathing in air containing oxygen.

instinct (IN-stingkt). Natural, untaught way of acting.

involuntary muscles (in-VAHL-un-ter-i MUS-elz). Those that

work automatically without our control.

iodine (EYE-uh-dyn). Element needed for proper functioning of the thyroid gland; also used as a test for starch.

kelp (KEHLP). Large brown seaweed usually found in the Pacific Ocean.

Kilauea (kee-low-AY-a). Volcanic crater in Hawaii.

Krakatoa (kra-ka-TOWA). Island in the East Indies that was formed from a volcano that arose from the ocean.

large intestine (LAHRJ in-TEHS-tin). Tube about 5 feet long through which solid body wastes pass.

latitude (LAT-uh-tood). Distance north or south of the equator measured in degrees.

lichen (LY-kuhn). Small plant that grows on flat rocks.

light second (LYT SEK-und). The distance light travels in one second; 186,000 miles.

limestone (LIM-stohn). Rock formed from marine animals.

limewater (LYM-woht-uhr). Solution that turns milky white when mixed with carbon dioxide.

liver (LIV-uhr). Bile-producing organ which also changes and stores certain substances from the blood.

loess (LOH-ess). Topsoil carried about by the wind.

magma (MAG-muh). Melted rock materials below the surface of the

earth; may flow from volcano.
magnetic North Pole (mag-NEHT-ik NAWRTH POHL). The arctic region of the earth to which a magnetic needle points.
magnetize (MAG-nuh-tyz). Cause a substance to act like a magnet.
malnutrition (mal-noo-TRISH-un). Condition caused by diet lacking in foods from basic food groups.
mammal (MAM-uhl). Animal that is warm-blooded and gives birth to live young
marble (MAHR-buhl). Rock formed from materials exposed to heat and pressure.
marrow (MAR-oh). The soft tissue in the center of bones.
mesquite (mes-KEET). Low thorny plant found in desert areas.
meteor (MEE-ti-uhr). A bright streak resembling a shooting star revolving around the sun.
methane (METH-ayn). Poisonous gas present on Jupiter.
microorganism (MY-kroh-OHR-guh-niz-um). One-celled form of life seen only with a microscope.
migrate (MY-grayt). Animals moving in large numbers from one place to another.
milt (MILT). Whitish fluid from the body of a male fish which fertilizes the eggs of the female.
mineral (MIN-uhr-ul). Certain elements required by the body for good nutrition.
mucous membrane (MYOO-kuhs MEM-brayn). Moist lining of organs which produces a liquid.
mucus (MYOO-kuss). Moist, slippery liquid produced by glands in

different areas of our bodies.
muscle (MUS-uhl). Bundle of body fibers which cause movement in some part of a living body; the fibers do this by becoming longer and then shorter.
naturalist (NACH-uh-ruhl-ist). Person who studies plants and/or animals.
niacin (NY-uh-sun). Vitamin found in foods such as wheat germ and peanut butter.
Northern Hemisphere (NAWR-thurn HEM-uh-sfir). Area of the earth from the equator to the North Pole.
nutrient (NOO-tree-ent). Food substance needed for proper growth and function of the body.
nymph (NIMF). Step in insect growth between the egg and adult forms.
opaque (O-PAYK). Objects that block the passage of light.
orbit (AWR-bit). The path of a planet as it travels around the sun.
organ (AWR-gun). Each part or member of a body system.
organism (OR-gan-ism). A living thing whose parts act together as a unit.
oxidation (ahk-suh-DAY-shun). Chemical change which produces energy; combination with oxygen.
oxygen (OK-suh-jun). Element needed by man for respiration.
pancreas (PAN-kree-us). Large

gland behind the stomach which produces a digestive juice.

pancreatic duct (*pan-kree-AT-ik DUKT*). Small tube connecting the pancreas and small intestine.

pancreatic juice (*pan-kree-AT-ik JOOS*). Digestive fluid made by pancreas which breaks up carbohydrates, fats, and proteins.

Parícutin (*pa-REE-koo-teen*). Volcano in Mexico.

passenger pigeon (*PAS-uhn-jur PIJ-uhn*). Bird that became extinct because of hunters.

patella (*pa-TEL-a*). The kneecap bone.

pellagra (*puh-LAG-ruh*). Disease caused by lack of foods containing niacin.

pelvis (*PEL-vus*). Bones of the hip region.

peristalsis (*pehr-ih-STAH- sis*). Muscular action which pushes food through the alimentary canal.

permanent teeth (*PUR-muh-nunt teeth*). The complete set of 32 teeth in the mouth.

perspiration (*pur-spuh-RAY-shun*). Loss of water from the body through the pores of the skin.

pharynx (*FAIR-ingks*). Cavity behind the mouth.

phases (*FAY-zet*). Changing appearance of the moon during one month.

phosphorus (*FOS-fuh-rus*). Essential mineral found in milk foods.

physical change (*FIZ-uh-kul CHAYNJ*). Change in form of matter such as from a solid to a liquid.

pituitary (*pi-TYOO-i-ter-ee*). Gland at the base of the brain which controls the actions of other glands.

planet (*PLAN-ih-t*). Any of the nine large bodies traveling around the sun.

plankton (*PLANK-tuhn*). Material found in water made of free-floating algae and microscopic animals.

plasma (*PLAZ-ma*). Liquid part of the blood that carries digested food.

plateau (*pla-TOH*). High area of flat land.

platelets (*PLAYT-letz*). The part of blood that aids in forming clots.

pod (*POHD*). The seed container of plants such as peas or beans.

Polaris (*poh-LAR-is*). The North star which does not change its position.

pores (*PAWRZ*). Holes or openings in the skin through which perspiration passes.

porous (*PAWR-us*). Materials containing empty spaces.

posture (*POS-chur*). The way a person holds his body.

protective coloration (*pruh-TEK-tiv KUL-uh-ray-shun*). The blending of an animal with the color of its surroundings.

protein (*PROH-tee-in*). Food that builds up and repairs body tissue.

protractor (*proh-TRAK-tur*). Device used to measure angles.

ptarmigan (*TAR-mi-gan*). An arctic bird whose feathers are white in winter and change to brown in the spring.

Ptolemy (TOL-e-mee). Greek astronomer who believed the earth was the center of the universe.

pulmonary artery (PUL-mo-ner-ee AHR-tuh-ri). Large blood vessel leading to the lungs.

pulp (PUHLP). Inner part of a tooth containing nerves and blood vessels.

radius (RAYD-ee-us). One of the bones of the lower arm.

rectum (REK-tum). Muscular bag at the end of the large intestine.

red blood cells (RED BLUHD SELZ). Those cells that carry oxygen to all parts of the body.

reflection (ri-FLEK-shun). Image of an object in a mirror or on a shiny surface.

reflex (REE-fleks). Action over which we have no control.

refraction (ree-FRAK-shun). Bending of light rays as they pass from one substance to another.

residual (ree-ZID-yoo-al) **mountains**. Those formed by the erosion of wind, water, and ice which sculptures raised land.

respiratory system (re-SPYR-a-to-ree sis-tum). Organs involved in the processes of inhaling and exhaling.

revolution (rev-uh-LOO-shun). Movement of the earth around the sun.

rib cage (RIB KAJ). Area of the body containing the heart and lungs protected by 24 ribs.

riboflavin (RY-boh-flay-vun). Vitamin found in milk, green vegetables, and eggs.

rickets (RIK-its). Disease caused by lack of Vitamin D in the diet.

root (ROOT). Underground part of a plant which holds it in place and takes in nourishment.

rotation (roh-TAY-shun). One complete turn of the earth on its axis.

saliva (suh-LY-vah). Liquid in mouth that moistens food.

salivary gland (SAL-i-var-ee GLAND). Organ that produces juices that aid in food digestion.

sanctuary (SANGK-choo-eh-r-i). Protected place for plants and animals.

sandblasting (SAND-blast-ing). Method of cleaning the soiled stone of buildings by using sand to wear away the dirt.

sandstone (SAND-stohn). Soft rock formed from sand that has been under great pressure.

sap (SAP). Liquid circulating through the tissues of trees and small plants.

satellite (SAT-uh-lyt). Man-made body shot into orbit around the earth or sun.

scallop (SKAL-up). Shellfish with rounded double shell.

scapular (SKAP-yu-luhr). Shoulder blade bone.

scurvy (SKUR-vee). Disease caused by lack of vitamin C.

sea urchin (SEE UHR-chin). Ocean animal with a hard shell-like body covered with spines.

sediment (SED-uh-munt). Particles of rock and soil that settle to the bottom of a river.

seismograph (SYZ-mo-graf). In-

- strument that records the vibrations caused by earthquakes.
- shale** (SHAYL). Rock formed from clay which has hardened.
- shooting star** (SHOOT-ing STAHR). Another name for a meteor.
- skeletal muscles** (SKEL-uh-tul MUS-elz). Those that move the bones of the skeleton.
- skeletal system** (SKEL-uh-tul SIS-tum). The bones that form the framework of the body.
- skin** (SKIN). The outer covering of the body.
- small intestine** (SMAWL in-TEHS-tin). Tube about 20 feet long extending from the stomach to the large intestine; it absorbs digested food.
- sodium** (SOH-dih-uhm). Element contained in table salt.
- sodium chloride** (SOH-di-uhm KLOH-eyed). The chemical name for common table salt.
- solar day** (SOH-lur DAY). The time on one day when the sun is highest in the sky, to the time on the next day when it reaches the same position.
- solar system** (SOH-lur SIS-tum). The sun, planets and all the heavenly bodies that revolve around it.
- solvent** (SAHL-vunt). A material, usually a liquid, able to dissolve other materials.
- Southern Hemisphere** (SUTH-urn HEM-uh-sfir). Area of the earth from the equator to the South Pole.
- space probe** (SPAYS PROHB). Vehicle whose purpose is to travel to another body in the solar system or universe.
- spawn** (SPAWN). The depositing of eggs by a female fish.
- sphere** (SFEER). Body that is perfectly round.
- spinal column** (SPY-nul KOL-uhm). Backbone extending from the base of the skull to the base of the hip bone.
- star** (STAHR). Any of the heavenly bodies other than the moon and planets.
- stationary** (STAY-shuh-neh-ry). Continually remaining fixed in one place.
- stickleback** (STIK-'l-bak). Type of male fish that builds a nest for its young.
- system** (SIS-tum). Body parts working together as a unit to perform a common function.
- tadpole** (TAD-pohl). Beginning growth stage of a frog or toad.
- telescope** (TEL-uh-skop). Instrument that makes distant objects appear larger.
- temporary teeth** (TEM-puh-rer-i teeth). The set of 20 teeth that are replaced by the permanent teeth.
- terrarium** (tuh-RAIR-y-uhm). An enclosure for growing plants indoors where small land animals such as lizards and toads can also be kept.
- theory** (THEE-uh-ri). An idea pictured in the mind.
- thoracic cavity** (thuh-RAS-ik KAV-uh-ti). The space inside the rib cage.

thyroid (THYR-oyd). Gland which regulates the rate at which we use up our food.

tibia (TIB-ee-uh). Bone of the lower leg; shin bone.

timberline (TIM-bur-lyn). Definite line on a mountain where the growth of trees ends.

time exposure (TYM eks-POH-zhur). Setting a camera to photograph for a specific period of time.

Tiros (TY-rohs). Name given to weather satellites.

tissue (TISH-oo). Material of which organ is composed.

topsoil (TOP-soil). The upper part of the soil which is best for growing plants.

trachea (TRAY-kee-a). The windpipe which extends from the mouth to the lungs.

transparent (trans-PAIR-unt). Substances that permit light to pass through them.

triceps (TRY-seps). Muscle over back part of upper arm.

trunk (TRUNGK). All the body except the legs, arms and head.

tuff (TUHF). Rock formed when volcanic ash hardens.

ulna (UHL-nuh). One of the bones of the lower arm.

underground stem (UHN-dur-ground STEM). Area of a plant that contains stored food.

Uranus (YOO-ra-nus). Planet discovered by astronomers in 1781.

ureter (yoo-REE-ter). Long narrow tube extending from each kidney to the urinary bladder.

urethra (yoo-REE-thra). Tube through which urine passes out of the body.

urine (YOO-rin). Yellowish liquid waste from the body.

valley (VAL-i). Low land area between mountains or hills.

valve (VALV). Part of an organ that prevents the backward flow of liquid.

vein (VAYN). Blood vessel in which blood flows toward the heart.

ventricles (VEN-tri-k'lz). The two lower chambers of the heart.

villi (VIL-eye). Small finger-shaped projections from the wall of the small intestine that absorb digested food.

vitamin (VY-tuh-min). Substance that aids and regulates bodily activity and growth.

volcano (vahl-KAY-noh). Break in the earth's crust which throws out melted rock, ashes, and steam.

voluntary muscles (VAHL-un-ter-i MUS-elz). Those muscles that can be controlled by choice.

warning coloration (WAWR-ning KUL-uh-ray-shun). The certain color an animal has on its body that attracts attention.

water cycle (WOHT-ur sy-kuhl). Movement of water from the earth's surface into the atmosphere and back again.

weathering (WEHTH-uhr-ing). Wearing away of rocks because of the continual action of wind and water; usually occurs over a long period of time.

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ACKNOWLEDGMENTS

The photographs in this book are from the following sources.

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We wish to thank Frances L. Orkin for assistance in obtaining the photographs on the following pages: 78, 112, 143, 150, 151, 154, 156, 157, 158, 159, 162, 163, 166, 183, 226.



